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HAWAII AGRICULTURAL EXPERIMENT STATION,
J. M. WESTGATE, Agronomist in Charge,
Honolulu, Hawaii.

Under the supervision of the STATES RELATIONS SERVICE,
Office of Experiment Stations, U. S. Department of Agriculture.

REPORT OF THE HAWAII AGRICULTURAL EXPERIMENT STATION.

1918.

Issued April 10, 1919

WASHINGTON
GOVERNMENT PRINTING OFFICE
1919

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[Under the supervision of A. C. TRUE, Director of the States Relations Service, United States Department of Agriculture.]

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LETTER OF TRANSMITTAL.

HAWAII AGRICULTURAL EXPERIMENT STATION,
Honolulu, Hawaii, July 15, 1918.

SIR: I have the honor to transmit herewith and to recommend for publication a report of the Hawaii Agricultural Experiment Station, 1918.

Respectfully,

J. M. WESTGATE,
Agronomist in Charge.

Dr. A. C. TRUE,
Director States Relations Service,
U. S. Department of Agriculture, Washington, D. C.

Publication recommended.
A. C. TRUE, *Director.*

Publication authorized.
D. F. HOUSTON,
Secretary of Agriculture.

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[1] Resigned June 30, 1918.

[2] In military service.

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REPORT OF THE HAWAII AGRICULTURAL EXPERIMENT STATION, 1918.

SUMMARY OF INVESTIGATIONS.

By J. M. WESTGATE, *Agronomist in Charge.*

INTRODUCTION.

The continued world food shortage of the past year revealed more clearly than ever the great dependence of the population of Hawaii on imported food products. Any interruption of shipping under such conditions immediately causes a severe disorganization in the distribution of food products. This has served to emphasize more and more the need of a greater production of locally grown foods. What the islands need most in an economic way is the development of diversified industries to provide a surplus of edible manufactured products which can serve as articles of export during normal times and which in times of dire necessity can be readily utilized to feed the local population. Sugar can be used only to a very limited extent to replace the starches in the human dietary, but, were such an industry as the manufacture of tapioca from cassava successfully launched, the cassava starch and flour could readily be utilized as food whenever necessary.

EMERGENCY WAR GARDENS.

Throughout the year, especial attention has been given to the development of the war-garden idea among those who became interested in doing something practical along food production lines. The station has continued to allot small plats of otherwise waste land to its laborers for the purpose of enabling them to maintain demonstration war gardens to serve not only as sources of foodstuffs but also as object lessons to the public, several of these gardens being located immediately in front of the station buildings. The gardens have also provided opportunity for successful demonstrations of the efficiency of spraying to overcome various insect and plant disease pests which are always troublesome under local conditions. The station has continued to supply cuttings, roots, tubers, seeds, and seedlings of such food plants as have not been regularly carried on

the local market. It has also been freely consulted in regard to the best means of overcoming the various handicaps to production encountered by local home gardeners.

COOPERATION WITH MILITARY POSTS.

Under the broad policy of the commanding officers, the military posts have continued to contribute materially to the available food supply of the islands through their system of company gardens. At a number of the posts as much as an acre has been assigned to a company and special details made for each company garden. These details ordinarily consist of individuals who having had special experience in market gardening, are naturally enthusiastic in the work, and they have cooperated intelligently with the station in many ways. It is a pleasure to record that at the recent Territorial fair one of the companies won the blue ribbon for the best exhibit of white potatoes.

COOPERATION WITH PRIVATE GROWERS.

Considerable attention has been given during the year to the development and furthering of cooperative relations between the station and numerous private growers and concerns throughout the Territory. In these cooperative arrangements the station provides the plan for some experiment or demonstration which promises to give valuable information to the section in question. The necessary seed is also usually furnished by the station, while the cooperating individual furnishes the land and labor. The chief beneficial result of this work is that the cooperating grower provides himself with a first-hand demonstration of the relative merits of several of the most promising agricultural practices in connection with the crop or crops in question under his immediate local conditions. There is, therefore, no question as to the application of the findings of such cooperative experimental work. In addition to this, the station benefits in that it obtains valuable additional data concerning the responses of the various crops to the individual treatment given. A further educational benefit is derived, not only by the cooperative growers but also by the neighboring farmers, from the first-hand demonstration furnished by such work as to the desirability of each grower being his own experimenter, at least on a small or simple scale. The growers soon come to realize the advisability of always leaving a check plat to serve as a basis of comparison when trying out any special treatment on field scale.

THE TERRITORIAL FAIR.

The Territorial fair, held primarily for the purpose of stimulating food production and food conservation, was one of the most successful enterprises ever launched in the islands. The result of the

food production propaganda of the past few years was demonstrated by the wide range of food crops placed on exhibit by growers representing nearly a dozen different nationalities. The cooperation of the military authorities in the way of equipment, organization, and program events contributed very materially to the success of the undertaking. All the agricultural institutions of the islands presented practical exhibits of their work, demonstrating either increased production or conservation of local foods.

One feature of no little interest was the daily exhibition of foods of the various nationalities, especially of the Japanese, Chinese, and Hawaiians, who demonstrated such of their foods as they considered best adapted for use as substitutes for wheat and other imported articles of diet.

Other very gratifying exhibits were those entered by a number of sugar plantations, showing the progress made in putting these plantations on a self-supporting basis as regards food for their laborers and feed for their work animals. One of the largest plantations presented evidence showing that it has been able to produce practically all the concentrate and roughage feed required by the thousand or more work animals in use on its properties. Another plantation company showed an interesting exhibit demonstrating the possibility of producing a form of alcohol from waste cane molasses for use as a substitute for gasoline. The same company has also developed a corn-meal grinding plant, a small model of which was in operation at the fair.

The general nature of the station's exhibits is indicated in Plates I, II, VI, and VII.

HORTICULTURAL INVESTIGATIONS.

The work of the horticultural division during the past year was principally concerned with the production of fruits and vegetables and especially the increased utilization of the banana, papaya, and tomato as food crops, particularly promising varieties of these being distributed as rapidly as propagating material could be made available. The division continued to give every possible support to the school and home garden propaganda work which has been very actively under way throughout the year.

One of the most promising phases of the work was a comprehensive test of numerous varieties of beans to determine the varieties best adapted for use not only as fresh string beans but also as commercial canning material for the pineapple companies, which necessarily are not in active operation during the considerable portion of the year when pineapples are out of season. It has been felt that the produc-

tion of beans for canning on a large scale would serve to keep the canning plants in operation and also provide work for the labor force of the pineapple companies throughout the year.

An interesting experiment was continued looking to the development of a tomato resistant to the melon fly. Various hybrids have been made between the tomato of normal size, which is much subject to the attacks of the melon fly, and several strains of small tomatoes, including the wild tomato, which are resistant to the ravages of this fly. Several of the resulting hybrids have proved of good quality and sufficiently resistant to the fly to make a very welcome addition to the food supply of the islands.

CHEMICAL INVESTIGATIONS.

The drying of Hawaiian fruits and vegetables was considered of such practical importance as to receive most of the attention of the chemical division during the past year. It is not ordinarily practicable to produce a perfectly regular supply of some perishable food crops throughout the year. The customary gluts in the market at periods of overproduction have always served as a great deterrent to many growers who would otherwise produce food crops on a much more extensive scale. The consuming public in the islands, as regards any particular food crop, is somewhat limited, and a very ordinary overproduction will rapidly glut the market. It has been felt that if the overproduction at any season could be taken care of by means of commercial driers, the market would be stabilized and the growing of such produce would be put on a much more substantial foundation. It is also felt that there may be a considerable future in the production of vegetables for drying for export on a commercial scale. The economy in shipping space, packing materials, etc., favors the drying of vegetables which are to be consumed at any great distance from the point of production. This project has been furthered through the effective cooperation of Frank C. Atherton, of Honolulu.

During the year a summary of all available analyses of Hawaiian feeding stuffs was brought together and published in convenient form for ready reference.[1]

During November and December, 1917, the chemist made an inspection trip through Florida, Cuba, the Isle of Pines, and Porto Rico, where much information regarding the production of pineapples was obtained. This trip was made possible through the cooperation of the Hawaiian Pineapple Packers' Association.

The fertilizer experiments of the division have been continued, principally with rice, bananas, and pineapples. The field work has been chiefly in cooperation with private interests, while preliminary

[1] Hawaii Sta. Press Bul. 53 (1918).

GENERAL VIEW OF EXPERIMENT STATION EXHIBIT AT TERRITORIAL FAIR.

EXHIBIT OF HORTICULTURAL DIVISION AT TERRITORIAL FAIR.

experiments on a small scale have been conducted in pots at the central station. Considerable progress has been made in the determination of the nature of the effect of excess manganese on plant growth.

EXTENSION WORK.

The vital necessity of increased efforts looking to the local production of foods for man and feed for animals has resulted in a marked increase in the activities and responsibilities of the extension division. Cooperative demonstrations, which in former years were arranged for only with considerable difficulty, have been rapidly arranged for in numerous locations, and in many instances it has been impossible to undertake as many of these as desired by various private individuals and concerns which have been interested in the emergency food-crop production work.

A most important advance in the extension work of the islands was the appointment of a number of county agents by the Territorial Food Commission shortly after the outbreak of the war. These agents, provided with automobiles and other means of transportation, have been most effective in bringing home to the producing public the best agricultural practices worked out in the islands. It has been found that numerous isolated farmers have developed practical ideas which are with profit being adopted by the other farmers throughout the islands, the county agents serving as a means of communication between the isolated farmers and bringing about an exchange of valuable ideas. The extension division has cooperated closely with the county agents. The superintendent of extension has acted temporarily as county agent for Maui County and by reason of his wide experience in agricultural extension work has been able to give much helpful advice and information to the other county agents, especially during the first few months of their work.

The demonstrations at Haiku, besides serving the general purpose of demonstration farms, continued to be the source of a great deal of valuable agricultural information. The central station avails itself of the opportunity offered to conduct various experiments on a field scale, thus largely overcoming the disadvantages of conducting all the experiments on small plats. The dependence put in the results obtained at the demonstration farms at Haiku by the leading agricultural companies of the islands as well as by the packing and canning industries speaks well for the permanent and practical value of the work being accomplished.

Much of the success of the agricultural phases of the Territorial fair was due to the inspiring efforts of the superintendent of extension in stimulating interest throughout the islands and thus securing many exhibits which otherwise would not have been made

such notable features. In addition, the superintendent also had immediate charge of the installation and general arrangement of the exhibits of the experiment station and of the decoration of the two large tents occupied by the agricultural exhibits. Practically every activity of the experiment station has been made the subject of further experimentation and demonstration on the Haiku farms, and in turn the best and most promising of the practices there worked out and developed have been passed on to the regular collaborators and private cooperators throughout the islands.

PLANT-DISEASE INVESTIGATIONS.

The rapid development of home and school gardens, together with the increased acreage planted to food crops on a large scale, has caused a material increase in the prevalence of various diseases and insect pests. The situation has been met as rapidly as possible through the determination of the most practical means of combating these various troubles. The use of the simplest spray pump and least complicated sprays has been emphasized, especially owing to the mixed population and the necessity of reducing such operations to their simplest possible form.

Probably the most serious disease which developed during the year is that of the banana, designated banana freckle or black spot disease. This has spread so rapidly from the valley in which it was first discovered that at the present time it seriously threatens the entire banana industry. The major portion of the pathologist's time during the coming year will probably be spent in an attempt to formulate a practical means of arresting the spread of this disease.

Another serious trouble was the taro rot, which caused material losses to many of the taro growers of the islands. Through the cooperation of one of the largest land-holding companies of the islands, experiments have been inaugurated looking to the development of practical means of controlling this disease.

The Irish potato continues to be affected by a number of troubles, including the late blight, early blight, mite disease, and tuber moth. Practical methods for control of these troubles have been worked out, and while much remains to be done, it is gratifying to be able to record that marked increases in yields have been repeatedly obtained by growers who have carried out the recommendations of the station.

Field and laboratory observations have revealed the presence of numerous miscellaneous fungus diseases and insect enemies of a great number of economic plants, especially food crops. An annotated list has been prepared and as rapidly as possible the most important troubles are receiving detailed attention.

AGRONOMIC INVESTIGATIONS.

In common with the efforts of the other divisions of the station, the agronomic work was directed chiefly along the lines of the production of forage and feed crops for animals and food crops for man.

The corn investigations have shown the variety introduced from Guam to be very resistant to the attacks of the corn leaf hopper and to give much higher yields than were obtained from any of the strains received from the mainland. The entire seed crop produced by the station is being used for the purpose of increasing the acreage of this strain of corn as rapidly as possible throughout the islands.

The work with the edible canna has been most promising, yields at the rate of over 40 tons of tubers per acre having been obtained 8½ months after planting. The station has made numerous distributions of tubers to individuals who have planted them as temporary ornamental plants in their yards, for the purpose, however, of utilizing them as an emergency food crop in case of necessity. The scarcity of tubers has prevented the planting of any considerable areas to this crop, it having been considered better to start numerous small patches from which additional plantings could be made in the immediate neighborhood of the initial plantings.

The Castner substation continued under the immediate oversight of the agronomy division, although the horticultural division has started some pineapple experiments and the chemical and pathological divisions cooperated in planning and carrying out experiments involving chemical and pathological features. The high percentage of manganese in the soil makes the problem of forage and food crop production very complicated, especially when combined with a low rainfall. Pigeon peas and sorghum appear to be very promising sources of forage. A heavy application of manure enables a number of food and forage plants to make a satisfactory growth in spite of the high manganese content of the soil.

GLENWOOD SUBSTATION.

The policy of the Glenwood substation, as compared with that of previous years, was changed somewhat during the past year. Upon the recommendation of the station, the Hilo Board of Trade appointed a Glenwood substation committee to keep in touch with the needs and activities of the substation and to serve as an intermediary between various interests, agricultural and otherwise, on the island of Hawaii and the Glenwood substation. The agricultural problems of the section in question are numerous and difficult, and the methods of approach are not always clear. The judgment of those having the policies of the substation practically in hand, combined with the

counsel afforded by the board of trade committee, has done much to enable the station to carry on its work with a very satisfactory local support.

The increasing importance of food-crop production has led to the placing of additional emphasis on this line of investigations. Numerous varieties of the standard food crops have been placed under test to determine their adaptability to the peculiar local conditions. The poultry flocks continue to occupy a prominent place in the substation's activities, having proved a most valuable and profitable line of work. The trap-nest records of the selected portions of the flocks have been so satisfactory that the demand for hatching eggs has been greater than could ordinarily be supplied. The dairy, having proved unprofitable during a series of years, has been materially reduced in size. The Guernsey bull has continued to give satisfactory results throughout the neighborhood, and his services are being continued.

In addition to the experiments and demonstration work under way at the substation, the superintendent has spent two days of each week doing county-agent work for about 20 miles in each direction in the district surrounding the substation. He has also kept in touch with the work being done by the Territorial county agents in the other sections of the islands.

PUBLICATIONS.

Much of the information acquired by the station has demanded immediate presentation to the public. It is a pleasure to record the hearty cooperation in this work which has been accorded by the local papers throughout the islands in publishing the various articles submitted by the station's staff. Practically without exception the station has prepared each week one or more articles on timely agricultural topics which have been carried by one or more of the local papers. The quick response on the part of the public to such of the articles as suggested calling at the station for additional information or for seeds or cuttings of food plants has been ample demonstration of the promptness with which these messages reached the reading public.

The following publications have been issued by the station during the year:

Annual Report for 1917.

Bulletin 44, The Litchi in Hawaii.

Press Bulletin 53, Composition and Digestibility of Feeding Stuffs Grown in Hawaii.

Extension Bulletin 3, Emergency Series I, Field Production of Beans.

Extension Bulletin 4, Emergency Series II, Methods of Combating Garden Pests.

Extension Bulletin 5, Emergency Series III, Peanuts—How to Grow and Use Them.
Extension Bulletin 6, Emergency Series IV, The Banana as an Emergency Food Crop.
Extension Bulletin 7, Emergency Series V, Drying as a Method of Food Preservation in Hawaii.
Extension Bulletin 8, Emergency Series VI, Bean Spot Disease.

REPORT OF THE HORTICULTURAL DIVISION.

By J. Edgar Higgins.

The unusual conditions brought about by the war, demanding that every energy, not only of the Government but of the individual, be focused upon the one supreme object, have made it necessary to suspend in part the usual investigations looking to the betterment of horticultural practice and the improvement of plants in order to assist in the more immediate application of the best-known agricultural practices to crop production. A maximum production of food is the present necessity, and while the regular horticultural projects have not been lost sight of, much more attention than usual has been given to what may be termed extension activities. The greatly augmented local correspondence and the increasing volume of personal inquiry at the station bear testimony to the enlarged interest in the production of fruits and vegetables.

BANANA PROPAGANDA.

An extension bulletin[1] by the horticulturist on the banana as an emergency food crop had its origin chiefly in this problem of emergency food supply and also in part in the general need for a brief statement of cultural methods, there having been many requests for such information which it has been impossible to supply since the banana bulletin[2] of the regular series has been out of print. One object of the work was to point out some of the possibilities of the banana as the basis of a large and profitable industry which, in the event of the withdrawal of other products, could supply a substitute for the greater part of the farinaceous or starchy foods for the whole of the island population. It is a well-known fact that in many tropical countries the banana is one of the principal food crops of the population, but in Hawaii it is used chiefly as fresh fruit, little attention being given to the many ways of preparing it for the table, while banana flour and banana "figs," or dried fruit, the two most

[1] Hawaii Sta. Ext. Bul. 6, Emergency Ser. IV (1917).
[2] Hawaii Sta. Bul. 7 (1904).

concentrated forms, are practically unknown. The bulletin discusses the production of the banana, its food value per acre yield as compared with other staple crops, some of the various forms in which the fruit may be concentrated, such as banana flour and banana figs, and also the present production and possible increase in plantings in Hawaii.

The banana situation became somewhat complicated during the year when the ships used in carrying the fruit to San Francisco were one after another commandeered for war purposes, thus rendering it impossible to get more than a small portion of the fruit to market. No appliances were at hand to dry bananas or otherwise put them in nonperishable form. The station, through Mrs. J. M. Westgate, had worked out methods some months previous by which baked banana pulp could be mixed with wheat-flour dough, replacing one-third of the weight of the flour. The bread thus made was of excellent flavor, texture, and appearance. Various modifications of this method were devised by individuals and by the large bakeries for the use of bananas in bread, and this was found to constitute an outlet for considerable quantities of the fruit. A campaign for the increased consumption of bananas was instituted by Honolulu business organizations and supported by the local press. These combined efforts were to some degree successful in relieving the congestion of this fruit upon the market and in saving wheat and other imported foodstuffs. The prices received for bananas for such uses, however, were decidedly less than the net receipts per pound on fruit that had been shipped to the mainland. This fact, combined with the prospect of inadequate shipping space for some time to come, has resulted in diverting some of the banana lands to other crops. The present abnormally high price of sugar and the urgent need of all that can be produced tends to cause all suitable lands to be planted to sugar cane.

SCHOOL AND HOME GARDENS.

The horticulturist, as in the year previous, acted as one of the judges of school and home gardens in connection with the prize contests conducted by the Honolulu Star-Bulletin, visiting a large number of the home gardens and all of the school gardens on the island of Oahu several times. The home gardens were so numerous and so widely scattered that it was necessary for the judges to apportion among themselves the work of examination. The best of those reported by the different groups were then seen and compared by the entire board of judges for the awarding of prizes. The importance of this work can not easily be overestimated, for it has resulted in very keen competition and interest in the cultivation of the soil

not only at the schools but at the homes. Better still, this interest has been reflected in the general community.

Concerning this work, the Hon. Franklin K. Lane, Secretary of the Department of the Interior, on his visit to Hawaii, spoke in part as follows:

I have been deeply gratified at the spirit and ability which the Territory's children have put into their gardens and impressed with their realization of the significance of what they are doing.

Through the stimulus given by this early movement, hundreds upon hundreds of gardens have been cultivated in every section of every island, and it is deeply impressive that this year more than 5,000 children were engaged in the Star-Bulletin contest, and, in addition, carried on active work for the Red Cross, for war saving stamps, and Liberty bonds.

TERRITORIAL FAIR.

Another extension activity has been in connection with the First Territorial Fair of Hawaii, held at Honolulu from June 10 to 16, inclusive. In connection with committees on field crops, fruits, and vegetables, and the committee on plants and cut flowers, preparations were made several months in advance to bring together the varied island products in a successful exhibition of large educational value which would serve particularly as an inspiration to greater production. The results, so far as they can be judged at this time, were highly satisfactory, a large and varied collection of products having been presented. Some points were also noted where greater emphasis should be placed at another fair.

Among the horticultural features meriting special mention was a collection of new seedling taros produced by G. P. Wilder, of Honolulu. In view of the importance of the taro plant to the whole archipelago and the failure of the crop in many places, a record should be made here of this, the first attempt, so far as known, to produce seedling varieties resistant to the prevalent diseases or otherwise superior to those that have been long in cultivation. The horticultural division of the station was able to extend to Mr. Wilder its propagating facilities for starting these seedlings, and it desires in every way possible to assist such important work.

A significant feature in the vegetable exhibit was the large number of cucurbitaceous fruits, including squashes and pumpkins grown at comparatively low altitudes. For many years these, with the exception of a few varieties, have been almost impossible of successful production because of the prevalence of the melon fly (*Dacus cucurbitæ*). The large number of specimens shown would seem to indicate that the melon fly's natural enemies introduced by the Territorial Board of Agriculture and Forestry have had an appreciable effect in checking the pest.

In the room occupied by the Hawaii Experiment Station, the division of horticulture presented a number of new plants, including rare varieties of litchi, new selections of algaroba, mate or Paraguay tea (*Ilex paraguayensis*), also roselle, Macadamia nuts and seedling trees, etc. A demonstration of the method of growing pineapple seedlings was made, showing the germination of the seeds and the care of the young plants up to the time when they are ready to be set out in the field. The budding of the avocado was illustrated by a number of trees, showing the different stages from the making of the incision in the stock to the completed process with the stock healed over where it had been cut off above the bud. A collection of tropical fruits in preservative fluid in museum jars was shown, including about a dozen varieties of avocado representing some of the best kinds discovered among the thousands of seedlings growing chiefly on the island of Oahu. Some citrus fruits grown at the station were shown fresh, also fruits of the snake gourd (*Trychosanthes anguina*) and of some of the papayas bred at the station were placed on exhibition and cut from time to time to demonstrate their qualities to especially interested observers (Pl. II).

DISTRIBUTION OF PLANTS.

It is the purpose to confine this work chiefly to dissemination of varieties bred at the station or to new introductions for further trial, as it is not considered the function of the station to send out seeds and plants of varieties easily secured from dealers. Wednesday afternoons and Saturday mornings were designated as distributing hours. There has been a larger demand than in any previous year for seeds and plants of the kinds of papaya and tomato in process of breeding at the station, and many thousands of these have been placed, usually in small allotments. Some varieties of sweet potatoes that had been under observation were placed with the division of agronomy to be disseminated with other varieties which that division had been growing. Several varieties of roselle also have been sent out. In the distributions, emphasis has been placed this year upon such plants as yield a rapid return in food products.

BEAN TESTS.

It is difficult to overestimate the value of beans as a food crop. The high protein content of the dried seeds is well known, and fresh and canned string beans, and also canned lima beans, are becoming more popular every year. Hawaii has produced only a small part of the dried beans that it consumes, and until the season of 1917–18 had never canned beans in any form on a commercial scale. This Territory may well profit by the experience of Porto Rico, that island having changed since the beginning of the war from a large importer

to an exporter of beans. There are every year hundreds of acres of land in process of preparation for pineapple planting that would be benefited by the growing of a crop of beans and the plowing under of the vines. After the pineapple plants have been set out, there are several months during which they occupy only a small portion of the land upon which they stand, and it is probable that one crop of a compact, nontrailing variety of beans could be grown between the rows without any injury and possibly with benefit to the pineapples.

The high price of canned string beans in the American markets in the autumn of 1917 attracted the attention of Hawaiian canners. It appeared that Hawaii might produce a crop during the winter season and find a comparatively bare market, and to this end a small acreage was planted and the crop canned. Very few data, however, were available as to the varieties best adapted to Hawaiian conditions, although the experiment station had in part foreseen the need of information and had begun some variety tests. J. H. Cowan, of the horticultural division, began a series of such tests on October 1, 1917, by planting at the station the following varieties: Giant Stringless Green Pod, Stringless Green Pod, Black Valentine, Early Refugee, French Mohawk, Canadian Wonder, Six Weeks, Refugee Wax, Prolific Black Wax, Golden Wax, Ventura Wonder Wax, and Davis Kidney Wax. The first picking was made from these on November 19, the second on November 28, and the third and last on December 6. The data are given below:

Results of variety tests with beans.

Variety.	First picking.			Second picking.			Third picking.	Total weight of crop.	Percentage of total crop[1] stung by melon fly.	Estimated yield per acre.	
	Weight of crop.	Number of pods.	Percentage of pods stung by melon fly.	Weight of crop.	Number of pods.	Percentage of pods stung by melon fly.	Weight of crop.			Total weight.	Weight of sound pods.
	Lbs., oz.			*Lbs., oz.*			*Lbs., oz.*	*Lbs., oz.*		*Lbs.*	*Lbs.*
Giant Stringless Green Pod	12½	69	35.2	2 12½	224	1.8	1 2	4 10¾	7.5	6,783	6,275
Stringless Green Pod	3 6½	297	47.02	2 14½	203	5.72	5	6 9½	21.2	9,534	7,513
Black Valentine	2 ½	219	47.9	2 8½	229	.43	5	4 14	16	7,078	5,946
Early Refugee	2 13½	405	.....	4 10½	568	.....	1 7½	8 15½	.....	12,999	12,999
Stringless Refugee	2 0	238	2.1	4 8½	415	.....	1 8¾	8 1¼	.76	11,729	11,640
Canadian Wonder	5 1	440	11.11	4 10	417	1.7	11	10 6	5.9	15,064	14,176
Six Weeks	1 13½	174	4.8	2 5½	202	.....	12½	4 15½	2.1	7,191	7,040
Refugee Wax	1¾	14	.....	12	80	.....	12	1 9¾	.....	2,336	2,336
Prolific Black Wax	2 3¾	234	3.08	3 2	232	.43	1 ½	6 6¼	1.7	9,279	9,122
Golden Wax	2 ¾	213	18.3	2 3	220	.91	1 2¼	5 6	8	7,804	7,180
Ventura Wonder Wax	2 2¾	223	1.36	2 5½	202	.....	15¾	5 8	.7	7,986	7,930
Davis Kidney Wax	2 0	193	8.04	2 14	222	.....	11½	5 9½	3.6	8,122	7,830
French Mohawk	3 14¾	328	15.9	1 12	257	1.2	9¼	6 4	9.6	9,097	8,224

[1] On basis of first and second pickings only, no records being available for the last picking, probably because of very slight injury.

It was found that an important factor in successful bean production lies in the susceptibility of the different varieties to the attacks of the melon fly. A careful count was made of the number of sound pods and of those stung in each of the first two pickings. In the last picking no such segregation is recorded, presumably because of the comparatively light infestation. It will be observed that Early Refugee and Refugee Wax received no injury whatever from the fly, the Stringless Refugee (not wax) and the Ventura Wonder Wax have each less than 1 per cent injury, 21 per cent of the Stringless Green Pod was stung, and varying degrees of susceptibility were shown by the other varieties. A noteworthy fact for which no explanation can be offered is that there was uniformly a very much higher percentage of infestation in the first picking than in the second.

The yields recorded in the column "Total weight of crop" are for an area of 30 square feet only, the tests having been begun on a small scale. Acre yields are calculations on this basis. They are valuable not so much in showing what yields may be expected from an acre as in showing the relative yielding power of the different varieties. In the last column, deductions have been made for the injured pods so as to show the relative yielding power of the varieties in terms of sound pods. Among the wax beans, the yield of sound pods is rather uniform in the varieties tested, except in the case of Refugee Wax, where it falls to less than one-third of that of the other varieties, notwithstanding the fact that its competitors suffered more or less severely from melon fly attacks.

The first eight varieties listed in the table are green podded. The Canadian Wonder is the heaviest yielder, but in respect to stringlessness and other qualities requisite in a first-grade bean for canning or for table use, it was not equal to some of the others. After careful tests of cooking qualities, flavor, texture, and absence of strings, it was concluded that the Stringless Green Pod, the Early Refugee, and the Stringless Refugee were of most promise as green beans for canning purposes or for table use under the conditions existing at the station.

Similar variety tests, including also some varieties of Lima beans, were undertaken on a somewhat larger scale in the pineapple lands of Aiea and Halemanu, both on the island of Oahu. Various combinations of fertilizers were applied in plats running at right angles to the rows. It is regrettable that, owing to the distance from the station and the impossibility of giving them continued close attention, these plantings suffered so severely from sudden insect attacks that no accurate data can be given as to the yields. In both cases the insects were cutworms and Japanese beetles which could probably have been completely controlled had the need been known in time.

The Stringless Green Pod appeared to be one of the best at Aiea. The fertilizer plats indicated the need of both phosphoric acid and nitrogen, the best appearing plats both at Aiea and at Halemanu being those to which was applied 1,500 pounds of acid phosphate and 500 pounds of sulphate of ammonia per acre.

TOMATO BREEDING.

The melon fly is the greatest enemy of tomato growing in Hawaii, the tomatoes in the local markets usually having been picked green and allowed to color in the house or store, where flies can not get at them. Such fruits do not attain the natural color and are quite lacking in flavor. As in the case of beans, there are wide differences in susceptibility to fly attack among tomatoes, but all of the large red-fruited varieties introduced and tested here have been found to be quite subject to attack. A small wild-growing sort, doubtless an escape from cultivation, appears to be immune, and a very large degree of resistance or immunity is possessed by the "pear" and "plum" varieties tried. But as all of these are small-fruited sorts, it seems desirable to combine, if possible, the fly-resistant character with the greater size of some of the standard kinds usually grown on the mainland. Mr. Cowan undertook the work of making certain crosses with this aim in view and also to determine, if possible, what constitutes the resistant character. It is regrettable that his work was terminated by Mr. Cowan's entry into military service before completion, but some valuable results were attained which are recorded here.

Flowers of the Earliana were crossed with pollen from the small wild form (Pl. III, fig. 1). The Earliana is a symmetrical, smooth variety, of small to medium size, bearing many of its fruits in clusters, while the small wild form is very symmetrical and round and also bears its fruits in clusters, but it is only about five-eighths inch in diameter. The first generation was variable and intermediate in size between the two parents, but all the fruits appeared to be free from infestation, except where otherwise injured (Pl. III, fig. 1). Several plants were selected, and seeds were taken from these for planting. The second generation also is recorded as having been free from attack at the station, and many thousands of seeds and seedlings of this generation were distributed for further trial. It was not possible to get any accurate record of the behavior in the majority of cases, but many favorable reports have been received, and there has been a strong demand for more plants.

Another cross was the Red Pear×John Baer. The fruits of the former are very small, distinctly pear shaped, and apparently immune to the melon fly, unless the skin is injured by birds, fungus diseases, or other causes. The John Baer is of medium size but is

attacked by the pest. The first generation of the hybrid is recorded as practically free from attack, but the second has shown some degree of infestation.

It seems improbable that resistance is due to any single character. By a study of the habits of the fly in confinement with immune fruits it is seen that the female fails to sting the fruit and deposit her eggs because the ovipositor slips on the surface of the skin and can not penetrate. This would appear to be due to a combination of slipperiness and toughness of the skin. With varieties of less resistant fruit, the fly in confinement in the laboratory will make repeated futile attempts to oviposit on various parts of the skin until finally it finds the vulnerable spot, frequently at the point where the stem is attached to the fruit and is covered by the calyx. If there is sufficient flattened area about this point to afford a good foothold, and if at the same time the circle protected by a tightly fitting calyx is not greater in diameter than the length of the ovipositor, eggs are deposited here just at the base of the fruit. A tomato with a slight depression about the stem end is subject to attack at this point, while one such as the Red Pear is difficult or impossible of attack. Again, if a tomato is of very uneven surface or "ribbed" (marked with depressed lines, as is the case with the Ponderosa type), it becomes extremely vulnerable at many points. Very few, if any, of these will escape destruction by the larva of the fly, while those forms that have but one vulnerable point will escape in larger numbers. There may be other elements entering into the problem, but from observations it would appear that any tomato to be bred for resistance to the fly must combine many characters, first, those relating to shape, of which there may be several, and, second, those relating to quality of skin, which must combine toughness with a degree of smoothness amounting almost to slipperiness.

PINEAPPLES.

The pineapple seedlings planted at Kunia, Oahu, in the autumn of 1916 began flowering in the spring of 1918. Several hundred seedlings were planted out in the autumn of 1917 at Waikakalaua in a well-prepared field which was being planted for the second time to the usual variety (Smooth Cayenne). These were thus placed under ordinary field conditions. The soil is rather highly manganiferous, but the fields are regularly sprayed with iron sulphate, which has been universally adopted in Hawaii to overcome the troubles due to manganese. This should give the seedlings a fair chance to demonstrate their suitability to such field conditions. The seedlings and the surrounding plants made practically no growth during the entire cool season, but on the return of warm weather they began, about the

latter part of May, to take on green color and to increase in size. This and similar experiences elsewhere point toward the desirability of planting out pineapple seedlings in the spring rather than in the late summer or autumn.

The seedlings at the station propagating yards and houses have been found to be very sensitive to the effects of temperature. In a glass house where they have protection from cold during the winter they will continue to grow and maintain a dark-green color, while plants of the same lot in soil similarly prepared and in the same sort of containers will lose their chlorophyll, take on a pink color, cease growth, and become weak in appearance when placed outside. These results are secured during the winter whether the plants are exposed to sunlight or partly shaded, though they begin to revive with the return of warm weather. Plate III, figure 2, shows two boxes of pineapple seedlings. The larger plants are a fair average of those being grown under glass, while the smaller constitute an equally fair sample of those growing on tables in the propagating yards, but the smaller plants in this case are 13 months older than the others. A thermograph record on the tables in the propagating yards during the cool season tends to run under the line of 70° F. for the greater part of the time, with a frequent rise for several hours of the day to between 70° and 75°, not infrequent falls during the night to between 60° and 65°, and an occasional record as low as 58°. In the glass house the temperature runs about 10° higher than outside, and the hours of lowest temperature of each night and early morning are shortened because the house retains heat. When seedling pineapples have become established in the fields, it has not been observed that they show greater sensitiveness to cold than do the Cayenne plants, but during the first year or more of their development they require considerable heat.

The work of growing more seedlings was continued so far as seeds have been available. Many hundreds of plants are now awaiting transplanting, including some hybrids of Queen×Cayenne, and several hundred more are ready for the first transplanting in the glass house.

REPORT OF THE CHEMICAL DIVISION.

By Maxwell O. Johnson.

Due to the national and local food shortage, much of the more technical research work of the chemical division was suspended during the past year, and attention was devoted to the determination of practical methods for the preservation and utilization of locally grown food crops. Experiments were made in drying Hawaiian food products and also in canning and preserving food crops. A

number of feeding stuffs were analyzed, and a summary of all analyses performed by the station was published. Some fertilizer experiments were made with pineapples and bananas. On a trip to the pineapple fields of the West Indies and Florida information was gathered of considerable value to the Hawaiian industry. The investigations concerning the biochemical influence of manganese were continued.

DRYING HAWAIIAN FRUITS AND VEGETABLES.

As drying is the simplest and cheapest method of food preservation, an extensive investigation is being made of the drying of Hawaiian food products. The banana, taro, cassava, sweet potato, edible canna, and Irish potato have been the chief subjects of experiment, as these crops are grown in Hawaii in sufficiently large quantities to make their production at times likely to exceed the immediate demand. An air drier constructed by the station with a capacity of about 150 to 200 pounds of wet material has given good results both in experimental and practical use in drying under Hawaiian conditions (Pl. IV). Experiments in drying the above-mentioned food products with this drier were published during the year.[1] Drying appears a particularly valuable method as applied to cassava, since it eliminates the two most serious objections to this important heavy-yielding food crop, namely, the content of hydrocyanic acid[2] of the fresh roots and their liability to rapid decay due to the moisture contained. Flour made from the peeled, dried cassava root appeared to be very promising as a wheat-flour substitute, as a very fine white flour was secured at low cost of production. A hot-air oven was used to dry the ripe banana, mango, and papaya, these giving dried products of good quality which appear to offer commercial possibilities for Hawaii.

A tower hot-air drier is in process of construction which will have a capacity of about 300 to 400 pounds of wet material. In this drier the air is heated by steam coils and blown over and through the trays loaded with the products to be dried. This drier is a unit which can be multiplied to give any desired capacity in commercial use. A small vacuum drier has been ordered, and this method of drying will also be investigated.

ANALYSES OF FEEDING STUFFS.

Due to the shortage and high prices of feeding stuffs, considerable interest has been manifested in home-grown feeds. In order to assist in developing local sources of supply, a summary of analyses of

[1] Hawaii Sta. Ext. Bul. 7, Emergency Ser. V (1918).
[2] Hawaii Sta. Rpt. 1916, p. 24.

Hawaiian feeding stuffs was published during the past year.[1] In this bulletin all the analyses of Hawaiian feeding stuffs made by the chemical division of the station were collected and arranged in a table convenient for comparison with standard tables of American feeding stuffs. On the assumption that the digestibility of Hawaiian-grown feeding stuffs is about the same as that of similar American feeding stuffs, a second table was prepared showing the approximate digestible nutrients and also the nutritive ratios for the different Hawaiian feeding stuffs.

TRIP TO THE WEST INDIAN PINEAPPLE FIELDS.

During the months of November and December, 1917, the chemist made a trip to the pineapple fields of Florida, Cuba, the Isle of Pines, and Porto Rico. The leading pineapple growers of the different districts were interviewed and an inspection made of their fields. Much information of interest to the Hawaiian pineapple growers was secured as to varieties, methods of planting, cultivation, fertilization, etc. The material is being prepared for publication as a bulletin of this station. The Abakka pineapple appearing desirable for introduction into Hawaii, steps are being taken for a trial of this variety on Hawaiian soils.

LIMING HAWAIIAN SOILS.

Most of the work on the effect of liming Hawaiian soils has been discontinued for a time. A preliminary report of an investigation of the reaction of Hawaiian soils with calcium bicarbonate solutions was published during the past year,[2] showing the relation of this reaction to the determination of the lime requirements of soils. A rapid approximate method of determining the lime requirements of soils given in this article appears to offer many advantages for routine soil examinations.

FERTILIZER EXPERIMENTS WITH RICE, BANANAS, AND PINEAPPLES.

Experiments have been made in applying dilute solutions of fertilizing salts to rice. Ammonium sulphate was the only treatment to give any notable increase in yield, a result confirming previous work[3] of the station as to the value of ammonium sulphate as a rice fertilizer. In similar spraying experiments with bananas, ammonium sulphate and potassium sulphate solutions stimulated growth. With pineapples, ammonium sulphate solution gave good results on man-

[1] Hawaii Sta. Press Bul. 53 (1918).
[2] Jour. Indus. and Eng. Chem., 10 (1918), No. 1, pp. 31–33.
[3] Hawaii Sta. Rpt. 1907, pp. 67–90; 1908, pp. 65–82; Bul. 24 (1911).

ganese soils. Nitrate of lime produced very good results with pineapples on windward Oahu, but due to war conditions, this fertilizer has unfortunately not been on the market for some time. As only a small amount of fertilizer can be supplied in a single spraying, this method of application does not appear practical except in certain special cases, as on manganese soils where ammonium sulphate can be added to the iron sulphate solution which is already being extensively used for spraying.

A small fertilizer experiment with pineapples was started in the fall of 1917, in the Waipio district of Oahu. Several insoluble fertilizers were applied singly and in mixtures directly in the heart of young plants. Up to the present time, dried blood at the rate of 250 pounds per acre has given quite striking results. In Porto Rico, "top feeding" the pineapple in this manner with cottonseed meal or dried blood is said to have fertilizing value and also to prevent "sanding." This method has been practiced in Hawaii only to a very small extent, but as a result of demonstration experiments at the station, it is now being quite extensively adopted by the Hawaiian growers.

MANGANESE INVESTIGATIONS.

The iron sulphate spraying treatment developed by this station[1] as a practical means for overcoming the very injurious effects of highly manganiferous soils on pineapples has met with continued success (Pl. V, figs. 1 and 2). Several thousand acres were added during the past year to the 5,000 which were noted last year as being under the spraying treatment.[2] In practice it has been observed that iron must be frequently supplied to the plant during the periods of rapid growth, but that comparatively few sprayings are necessary during quiescent periods.

Methods of treating the manganese soil before planting to supply iron to the plant have thus far given no success, with the exception of the use of stable manure, and in this method it appears that the pineapple is grown on the manure rather than on the soil. In a cooperative field experiment several promising methods of treating the manganese soil have been tried. As investigations have shown that sulphur is slowly oxidized in the soil, flowers of sulphur was applied to the manganese soil at rates of 500 to 3,000 pounds per acre in the hope that by the aid of the acid formed by this oxidation, possibly some of the immense quantity of iron locked up in the soil would be liberated. Additions were also made to the manganese soil, at rates of 1 to 6 tons per acre, of a red, very acid, upland soil containing apparently considerable quantities of available iron. A third

[1] Hawaii Sta. Press Bul. 51 (1916).
[2] Hawaii Sta. Rpt. 1917, pp. 7, 26.

FIG. 1.—HYBRIDIZING TOMATOES. WILD PARENT AT LEFT, EARLIANA PARENT AT RIGHT, HYBRID IN CENTER.

FIG. 2.—EFFECT OF HEAT ON PINEAPPLE SEEDLINGS.

Plants at right grown in glass house during cool season, those at left grown in the open.

AIR DRIER FOR VEGETABLES, SHOWING PROCESS OF DRYING AND DISHES PREPARED FROM DRIED PRODUCTS.

FIG. 1.—HIGH POWER SPRAYER USED FOR TREATING PINEAPPLES WITH IRON SULPHATE SOLUTION.

FIG. 2.—MACHINE DEVISED FOR SPRAYING 12 ROWS OF PINEAPPLES AT A TIME.

treatment tried was the application to the soil of bagasse soaked in very strong solutions of iron sulphate. The plants in these experiments, at present about 10 months old, have shown no striking differences as yet between the treated plats and the checks.

Series of experiments were made with rice grown in nutrient solutions to determine the effect of additions of manganese dioxid and of manganous sulphate. Preliminary experiments indicated that the effect of manganese depends largely on the amount of iron supplied by the solution. Accordingly, manganese dioxid was added to the nutrient solution at the rate of 0.4 gram per liter and manganous sulphate at the rate of 50 milligrams per liter, with ferrous sulphate supplied at rates of 5, 10, 20, 40, and 80 milligrams of iron per liter. With the smallest amount of iron supplied, which was, however, sufficient for the normal growth of the checks, manganese dioxid and manganous sulphate caused an extreme depression in growth, the plants in these solutions being light yellow in color with brownish spots. As the amounts of iron were increased up to the very excessive amounts supplied by the highest rate employed, the injurious effects of the manganese were overcome and growth approached that of the checks. Dipping the leaves of the plants at intervals in a dilute solution of ferrous sulphate was also partially effective in overcoming the injurious effects of manganese dioxid. This experiment, repeated with ferric chlorid and with ferric citrate as sources of iron, gave similar results.

Several investigators[1] have claimed stimulated growth as a result of adding manganese to nutrient solutions, but an examination of their work reveals, in most cases, that the effect on growth was determined only by rough measurements of the increase in the height of the plants and that the iron content of the nutrient solutions used was many times that necessary for normal growth and so excessive as to mask the injurious effects of manganese.

Further experiments planned in order thoroughly to check the results obtained have been temporarily held in abeyance by the emergency conditions at present prevailing.

PINEAPPLE WILT.

Serious trouble continues to be experienced with this disease in Hawaii. Burnt lime has been partially effective but can not be considered entirely successful in controlling wilt. In pot experiments a yellowish-brown soil was used on which in the field practically every plant had wilted. Under the well-drained con-

[1] Loew, O., and Sawa, S., On the action of manganese compounds on plants, Bul. Col. Agr. Tokyo Imp. Univ., 5 (1902–3), pp. 161–172; Pugliese, A., Sulla biochimica del manganese, Atti R. Ist. Incoragg. Napoli, 6. ser., 65 (1913), pp. 289–315.

ditions in pots no wilt occurred in any of the pots, even the untreated ones. The plants in the untreated pots showed a tendency to "grow out" of the soil and had only a few surface roots alive. Plantings made in a manganese soil under similar conditions had a very extensive root system. The best means for control of wilt at the present appear to be application of burnt lime before planting, planting in a single-row system on gentle ridges, keeping the soil well hilled up about the base of the plants, and applying air-slaked lime or a mixture of air-slaked lime and reverted phosphate in the heart of the plant.

REPORT OF THE EXTENSION DIVISION.

By F. G. Krauss.

The results of the work of the extension division during the past year were very satisfactory. It is gratifying to record increased interest in the work of this division on the part of practically every industry in the islands, the sugar and pineapple plantations, as well as the ranches, cooperating more closely than ever in the establishment of diversified agriculture in the Territory. The implement dealers and fertilizer manufacturers are also cooperating, while there was noted a marked tendency on the part of merchants to give increased preference to island-grown produce rather than to imported foods. During the year the superintendent of extension work has devoted about one-third of his time to extension and demonstration trips throughout the various islands, the balance of his time being spent in active charge of the Haiku substation (Pl. XI, fig. 1.)

COLLABORATORS AND COUNTY AGENTS.

Two additional homesteaders collaborated with the station during the year, John H. Midkiff at Kealakekua in the Kona homestead district on Hawaii and J. Anjo in the newly opened Haleakalea tract on Maui. The employment of collaborators in the various districts to serve as representatives of the division and to demonstrate on their own farms the most approved agricultural practices is proving a very satisfactory method of bringing the desired agricultural truths home to the farmer. There are now three collaborators on Hawaii and one on Maui, in addition to the substation and demonstration farms at Haiku in direct charge of the superintendent of extension. There is also one collaborator on the island of Kauai, while the island of Oahu is provided for by the central experiment station at Honolulu and the substation at Castner. Plans are under way for the establishment of a collaboratorship on the island of Molokai.

The work of the collaborators forms an important link in the agricultural-extension chain. Usually the collaborator has some demonstration work in progress on his farm, which is frequently the headquarters for supplying new and tested seeds and cuttings to the neighboring farmers. In this connection it may be mentioned that John de C. Jerves, the collaborator at Kalaheo, Kauai, has distributed more than a million cuttings of the now famous Madeira or Kauai sweet potato, which he was instrumental in bringing to the attention of the producing and consuming public.

The work of J. E. Gamalielson, collaborator at Kaumana, near Hilo, Hawaii, is especially noteworthy. He took over the management of the Glenwood Creamery Co., a cooperative organization of dairy farmers established through the efforts of the Glenwood substation, in August, 1913. A brief history of this cooperative effort, covering the five years of its existence, is given below, having been prepared by him:

A summary of business transacted by the Glenwood Creamery Co. year by year is presented for the five years of its existence. A beginning having been made the first of June, 1913, May 31 in each succeeding year has herein been considered as the end of the year.

In 1913, F. A. Clowes, then superintendent of the Glenwood substation, built and equipped a creamery at the substation for the purpose of assisting the farmers in the district to produce a good, marketable grade of butter and to find a market for it. After having operated the creamery for some months as part of the work of the substation, paying for the cream according to the butter fat contained in it and making and marketing the butter as the property of the substation, he made arrangements for and called a meeting of the farmers interested, which meeting was held on May 22, 1913.

The farmers then agreed to take over the operation of the creamery and have it operated for them on a cooperative basis and the product marketed the same way, each one to pay into the treasury of the concern $10 for each cow from which to furnish cream, to be paid in 10 monthly installments. The total amount so subscribed was $1,050. Interest-bearing notes were given for the respective sums subscribed and the secretary was authorized to deduct the monthly installments from what became due each of the respective subscribers each month, until the full amounts subscribed had been collected. This was to furnish working capital, as some additional equipment and an addition to the creamery building were needed. Mr. Clowes consented to remain secretary and manager for the concern, which he did until the end of August, at which time J. E. Gamalielson, of Kaumana, was elected secretary, as he lived nearer the market and it was considered easier for him to attend to the marketing, billing, collecting, and remitting to each man his share of the proceeds. Mr. Clowes remained in charge of the creamery and superintended production.

At the time the farmers took over the creamery, butter was selling at 45 cents per pound, wholesale, but about that time Australian butter was coming in and selling as low as 28 cents per pound, and the farmers were forced to discontinue operation of the creamery at the end of November, the same year. but each man made his own cream into butter which was marketed cooperatively.

Summary of business of the Glenwood Creamery Co. for the five years of its existence.

Year.[1]	Amount of butter marketed.	Average price per pound.	Total returns.	Cost of marketing.	Percentage of cost.
	Pounds.	*Cents.*			
1913–14	12,580	41.55	$5,234.56	$300.00	5.73
1914–15	12,683	35.78	4,534.38	291.19	6.5
1915–16	11,314	35	3,965.38	312.75	7.75
1916–17	5,174	38.35	2,036.46	122.92	6
1917–18	4,276	52.8	2,257.76	117.50	5.2
Total	46,027	39.16	18,028.54	1,144.36	6.35

[1] Each year ending May 31.

The falling off in production was caused by competition with imported butter, a number of farmers finding dairying unprofitable and giving it up. Later on the high cost of feed and labor forced them to do without grain feed, to milk only the best of the cows, and to let the others suckle the calves. Some of them had to leave the butter making to the women and children and go out to work for wages in order to meet the constantly increasing cost of supporting their families. At present, with better prices for the product, more butter is being made, but the demand for it being better more of it is being sold near where it is made and is not recorded here.

The cost of marketing covers salaries and telephone rent. Freight charges, which come to from one-half to two-thirds of a cent a pound, according to distance and amounts shipped, are not included.

In addition to his duties as secretary of the cooperative creamery, Mr. Gamalielson operates a successful dairy farm of his own. So far as is known, there is here installed the only set of mechanical milkers in the Territory. In addition to the dairy, a large flock of poultry is maintained, and skimmed milk is utilized to a large extent by the poultry. Both the dairy herd and the poultry flocks are fed largely from farm produce. The total area of Mr. Gamalielson's farm is 74 acres, of which 20 acres is classed as agricultural. This has recently been planted to sugar cane, and the remainder is rough pasture land of which a few acres has been planted to crops for the live stock and the household. Mr. Gamalielson's net average income during the past three years has been about $1,000 annually in addition to his living expenses.

John de C. Jerves, at Kalaheo, Kauai, is field foreman for the Kauai Fruit and Land Company and owns a five-acre homestead at Kalaheo. No one has better demonstrated the agricultural possibilities of a small tract of land well tilled than has Mr. Jerves. The most noteworthy individual activity on his part has been the introduction and distribution of the Madeira sweet potato throughout the islands. No variety is more widely planted now, nor has any other commanded a higher price on the Honolulu market. During a period of temporary overproduction of potatoes in certain seasons

of the year, Mr. Jerves has experimented with the feeding of the sweet potato to work mules, cattle, and swine. He finds that the feeding value of this crop, based on present feed prices, is approximately $20 per ton. Since the yield from a 6 to 8 months' crop is about 8 tons per acre, it will be seen that the potato may be made profitable as stock feed alone. Mr. Jerves was visited by the superintendent of extension work during June, 1918, and was found to be encouraging the production of corn, beans, and other crops by both small and large growers throughout the island of Kauai.

In the Waimea homestead district Alexander Arthur was appointed collaborator in 1916. Being one of the earliest settlers, he has a well-established diversified farm of approximately 80 acres. Mr. Arthur has been a successful corn grower and swine raiser. Potatoes, dryland taro, and beans succeed well, and his farm is becoming more and more a valuable demonstration unit.

The newly established collaboratorship at Kealakekua, to which John H. Midkiff was appointed in 1918, is centered in the thriving agricultural district of North Kona. Here many of the small homesteads were first opened for settlement. One of the main objects in establishing a demonstration unit at this place was to test new and promising crops under the direct supervision of the extension division. Mr. Midkiff is a graduate of the animal husbandry course of the University of Illinois. His interest in animal husbandry is indicated by his maintenance of a public service boar for the benefit of the hog raisers of the community. He has also established a free market at Kealakekua where the small farmer brings his produce for sale every Saturday.

The collaboratorship established in the newly opened Haleakalea homestead district on Maui in February is an attempt to help the new settlers from the beginning. J. Anjo, who has been closely identified with the opening of these lands and who has the interest of the settlers at heart, was considered the most suitable person to undertake the work in hand. Through the commendable community spirit shown by the settlers, 40 acres of the demonstration unit was broken up and has had two harrowings and a second plowing. A third plowing and disking will be necessary for the initial plantings of pigeon peas and Japanese cane to demonstrate their value for feeding purposes and to serve as temporary windbreaks until trees can be established. The establishment of this demonstration unit by the Territory marks an important advance in the development of the various homestead districts throughout the islands in that it recognizes the necessity of preliminary experiments and demonstrations for the benefit of the new farmers who take up the homesteads, often without the necessary capital to justify them in making what

may prove costly experiments in crop production. The different districts vary so greatly as regards soil and rainfall that what succeeds in one section is little or no indication as to what will succeed in a neighboring locality. This clearly indicates the necessity of preliminary work on the part of the extension and demonstration organizations of the islands.

Through the cooperation of the Haleakalea ranch, in the center of whose holdings is situated the Haleakalea homestead tract, the demonstration farm has been enabled to fence a part of its land. The most urgent need of this enterprise is financial assistance, either from the county or Territorial Government, for the completion of the fencing and the erection of a group of farm buildings consisting of a small residence, barn, and outhouses. The entire expense of the necessary equipment, which in itself would prove a valuable demonstration in efficient and economical building, should not exceed $2,500.

COOPERATION WITH TERRITORIAL COUNTY AGENTS.

The 1917 session of the Territorial legislature provided for the employment of a number of county agents throughout the islands. The closest sort of cooperative relationship has been in effect with these county agents. During the greater part of the calendar year 1917, the superintendent of extension work acted largely in the capacity of county agent for his particular district. He has also kept in close touch with the various county agents throughout the islands and has been of great assistance to them.

The following are abstracts from the report of the superintendent of extension work while acting as county agent for Maui for the period July 1, to December 31, 1917:

Total farms visited 108. Some of these were visited bimonthly, over 500 distinct visits having been made by the county agent and his assistants during the period of six months covered by this report.

More than 5,000 miles was traveled by automobile, and about 800 miles on horseback.

More than 100 acres of potatoes was sprayed for blight and insect pests.

Twelve thousand pounds select seed potatoes was distributed for the improvement of the potato crops in Kula and Makawao regions.

Three thousand packets of seed were distributed, most of these being of new and improved varieties grown at the Haiku substation.

More than 80,000 sweet potato, cane, and cassava cuttings were distributed from the Haiku substation.

A large amount of agricultural and food commission literature was distributed. Weekly agricultural letters have been prepared for the press, about 30 such articles having been published during the half year. Several talks on agricultural subjcts were also given before good sized audiences.

Plans for several agricultural projects have been prepared for private enterprises. In a number of cases the complete equipment will represent the outlay of thousands of dollars.

The bean-canning projects now under way are largely the outcome of the county agent's endeavors, and may result in the development of an important industry in the near future.

Numerous visitors have called at the substation and demonstration farms.

The correspondence and personal consultation with both large and small farmers have been extensive.

EXTENSION BULLETINS.

Supplementing the general agricultural propaganda of personal visits by the station and extension division staffs, extension bulletins were issued during the year[1] on the field production of beans, methods of combating garden pests, how to grow and use peanuts, bananas as an emergency food crop, and bean spot disease.

In addition to the above, numerous articles have been prepared for the local press in which practical subjects received immediate attention and reached a wide circle of readers. A number of talks on agricultural subjects were given in the rural communities by various members of the staff.

FIRST TERRITORIAL FAIR.

The various activities of the extension division were featured at the Territorial fair held June 10 to 16, 1918 (Pl. VI). The extension division exhibited its seed-selection work with potatoes, its home-grown concentrates for stock feeding, its seed-corn selection work, and the production of substitutes for wheat flour. In addition to this, a series of photographs showed the work in progress on the farms of the various collaborators throughout the islands.

EXTENSION OF NEW VARIETIES OF CROPS.

Special emphasis has been laid on the importance of obtaining the proper varieties of field, forage, and green-manuring crops. High yields of field corn were produced during the past season, notwithstanding the exceptional drought through which the crop was forced to pass. A considerable portion of the farm at Haiku produced shelled corn at the rate of 77 bushels per acre. The variety now exclusively grown on the demonstration farms is the New Era, a 100-day yellow dent corn developed by the extension division by hybridizing Gold Standard Leaming, Reid's Yellow Dent, and Funk's Ninety Day. This variety, which is each year growing in favor, during the past season was planted on 100 acres on the island of Maui. At the recent Territorial fair the first and second prizes for the best ear, and the first prize for the best 100 pounds of shelled corn were awarded to this variety. About 500 pounds of selected seed has been dis-

[1] Hawaii Sta. Ext. Buls. 3, 4, 5, 6, and 8 (1918).

tributed during the past three years, and a considerable seed trade is being developed for this variety by the corn growers on Maui.

The Japanese cane introduced by the extension division some years ago is each season increasing in general favor, no forage crop having withstood the severe drought of the last season better than this cane. One-half million cuttings have been distributed during the year to interested dairymen.

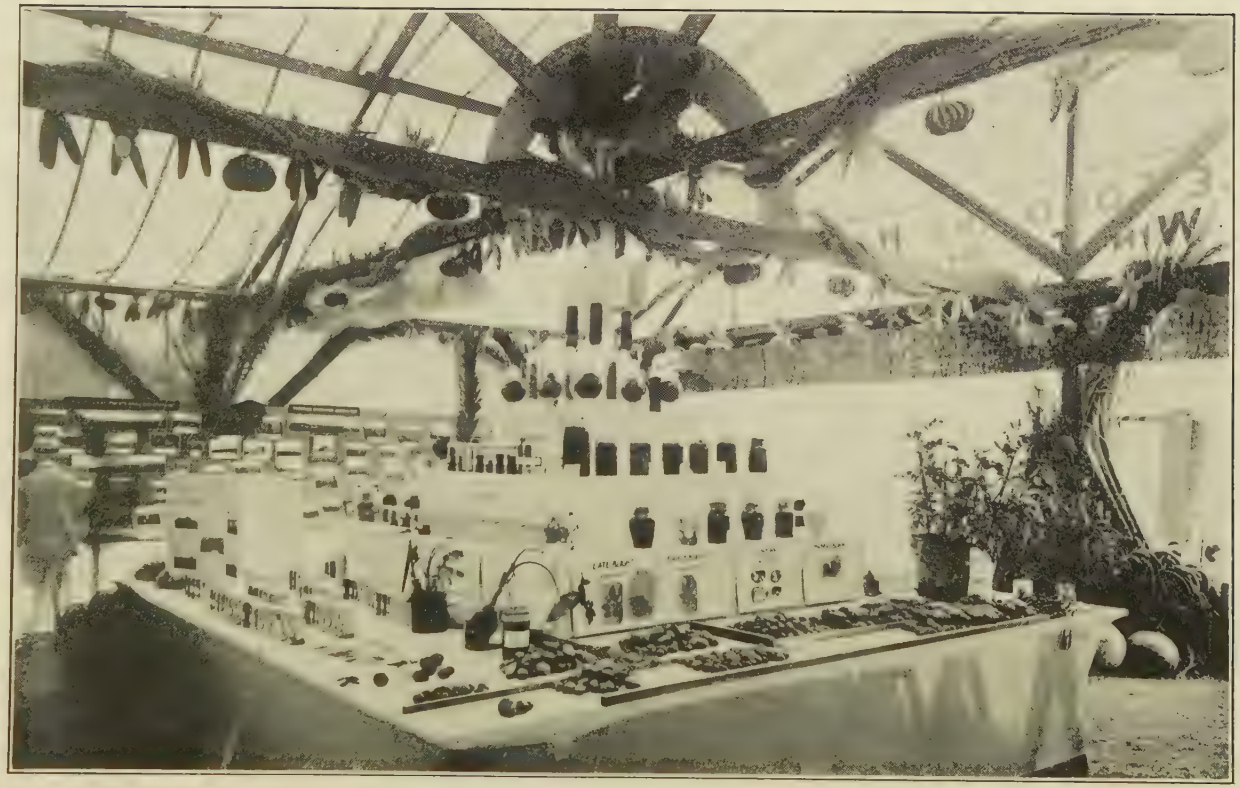
Cowpeas and velvet beans continue to be important crops, and are more extensively planted each season.

Perhaps the most promising crop now under cultivation at the Patterson demonstration farm, Haiku, is the 15-acre field of pigeon peas (*Cajanus indicus*) of the variety New Era. This planting was made in March, 1917, as an intercrop between corn rows. While the drought almost ruined the corn crop the pigeon peas continued to thrive and yielded heavy crops of both seed and forage. A quantity of the seed has been sold in advance for $200 per ton, while the cured forage with pods attached is bringing $40 per ton in the field. Meal prepared from the whole plant has been fed extensively and with satisfactory results to work mules, milch cows, and swine. It seems very probable that hundreds of acres will be planted to this crop during the coming season. The pigeon pea is to the poor dry waste lands what alfalfa is to the rich moist bottom lands of Hawaii.

LIVE-STOCK FEEDING PROBLEMS.

In connection with the development of the extension division farms at Haiku, Maui, constant effort has been made to maintain a balance between crops, live stock, and labor, it being realized that it is essential at the present time to make greater and greater efforts to conserve food, fertility, and labor. As a result of this policy the live stock has been built up until now there are 6 work mules, 4 milch cows, 100 laying hens, and a herd of about 40 head of swine, which are maintained on the 100 acres comprising the two demonstration farms. No produce leaves these farms except the selected seed used for the purpose of extending the improved varieties. The cull seeds, straw, and forage are fed on the place. There is no waste. The manure from the cattle is conserved and has added not a little to the fertility of the land. Vegetable matter not utilized as feed is plowed under as green manure. The labor has been equalized by the development of diversified projects until the working force is now of uniform size throughout the year, thus resulting in greater efficiency and economy. As an outgrowth of the experiments in regard to growing, milling, and feeding of home-grown concentrates conducted at the Haiku substation during the past three years, there has been developed in the past year at the Haiku ranch of the Maui Agricultural Co. a plant for the preparation of 10 tons of mixed home-

EXHIBIT OF EXTENSION DIVISION AT TERRITORIAL FAIR.



EXHIBITS OF PATHOLOGICAL (RIGHT) AND CHEMICAL (LEFT) DIVISIONS AT TERRITORIAL FAIR.

grown milled feed daily. This is designed to supplant the imported grain formerly required to feed the 1,000 head of work animals owned by the company in question

TRUCK CROPS.

During the past year, in cooperation with the Haiku Fruit and Packing Company an acre was planted to five varieties of string beans and an acre to different varieties of Lima beans. From these plantings the best varieties of each type, both for canning purposes and for yield, were determined. A representative from one of the largest mainland packing and canning concerns pronounced the Maui Red Kidney bean superior to the old Standard Refugee, Improved Stringless, and Kentucky Wonder. Among the Lima beans, the Fordhook and a special selection made by the extension division were considered the best of the five under test as regards suitability for canning.

Some progress has been made in the development of a new type of kidney bean for use where dried shell beans are desired. This work has resulted in the development of a variety which has been named the New Era Copper Kidney and which has yielded 40 per cent more beans under field conditions than any other of the numerous varieties under test. The quality also appears to be excellent.

Following up previous comparative trials of bean varieties, 100 sorts were under test during the past season, and a number of selections have been made and several crosses effected. These were shown at the recent Territorial fair, both as preserved specimens in the pod and as shelled seed.

The second annual test of some 20 varieties of onions has been completed. As in the previous test, the Bermuda type is far in the lead as to earliness, quality, and yield. However, several other varieties of long-keeping quality are giving promise, and it is believed that some may overcome the drawbacks of the Bermuda varieties.

Potatoes continue to form an important crop at the substation and demonstration farms. The third year of hill selection, both for increasing yields and obtaining a blight-resistant type, has shown some success. The fall crop of potatoes was exceptionally good where liberal applications of phosphate were made, especially in connection with the hill-selected seed. A yield of 180 bushels of marketable potatoes was obtained from one acre of Dibble's Russett, as compared with 100 bushels to the acre from unselected seed. At the present writing 23 varieties of potatoes and many selections are under test. The late blight is held in check by spraying with Bordeaux mixture. The potato industry is becoming more and more affected by the potato mite. Fortunately, lime-sulphur spray, or even sulphur alone in the proper form, is proving an effective remedy.

Much credit is due C. W. Carpenter, pathologist at the station, for the discovery of the nature of this new pest and a simple means for its suppression.

THE HOME VEGETABLE GARDEN.

The home vegetable garden has always been an important adjunct to the work with field crops at the demonstration farms at Haiku. An asparagus bed has been maintained for three years. Upland taro in several varieties is grown for household use. String beans and Lima beans are all-season crops, and a great variety of garden vegetables is grown to a less extent.

MISCELLANEOUS ACTIVITIES.

Several planting charts for field crops and vegetables have been prepared by the division for the Territorial Food Commisison, school garden officials, and others. The superintendent has also acted as judge for both the Star-Bulletin garden contest and the Maui County Fair Association garden contest. Several thousand packets of vegetable seed have been distributed where it was felt that the greatest good could be realized.

COOPERATIVE EXPERIMENTS WITH PINEAPPLES.

While the substation at Haiku since its inception has maintained a series of experiments with pineapples because of its location in an important pineapple region, it has only during the past year inaugurated an extensive project looking to the solution of the very important problems which have arisen in this industry, the importance of which is second only to that of sugar. Ten acres of pineapples is now being devoted to cultural, plant type, and fertilizer experiments with this crop. Much interest is being shown by the pineapple growers and packing companies in these experiments, and cooperation with the large pineapple companies is doing much to facilitate the progress of this work, which must necessarily take several years to complete. A number of duplications of the experiments are being voluntarily carried out by private growers, thus furnishing a source of additional data as to the response of the pineapple plants on different soil types and in different locations.

FERTILIZER DEMONSTRATIONS.

The use of superphosphate and reverted phosphate as fertilizers has shown remarkable results. The soils at Haiku show little or no benefit from lime, nitrogenous fertilizers, or potash. The use of phosphate fertilizers, however, in conjunction with green-manure crops, has given extraordinary increases in the yields of alfalfa, corn,

potatoes, beans, and onions. As an indication of the value of this work, it may be mentioned that 50 tons of these phosphate fertilizers have been used during the past year in the Haiku district alone, where previously less than a ton had been used, except as an ingredient of high-grade complete fertilizers.

REPORT OF THE DIVISION OF PLANT PATHOLOGY.

By C. W. Carpenter.

In the work of the year in the division of plant pathology, emphasis was placed on food conservation through the control of plant diseases and insect pests. In the interest of extension and demonstration work, field trips were made to all the principal islands of the Territory. The extension phase of the work was considered of paramount importance during the present emergency, and research on problems not promising prompt returns in food conservation is necessarily being held in abeyance. (Pl. VII.)

Throughout the Territory there has been a general awakening to the serious losses induced by plant pests and to the urgent need of practical control measures. The advice of the pathologist has been repeatedly sought in this emergency, and his suggestions have been faithfully carried out by the growers of food crops. The area in diversified crops was greatly increased during the year, mostly through the improvement of waste lands and the use of lands lying fallow. With those engaging in gardening for the first time in the islands, no doubt in some cases errors in judgment have led to the selection of unsuitable situations, but in the majority of cases coming to the attention of this division the failures reported were due to fungus and insect pests. Perfection in gardening was not to be expected in the first attempts, and while acquiring a knowledge of vegetable growing much has been learned of the habits of insect and fungus enemies which will be of value in the future.

The pioneer work started in 1916 by the pathologist in demonstrating insect and fungus pest control methods was continued on a much more extensive scale by the county agents. During the six months beginning with October, 1917, instructions regarding spraying were given by the county agents to 587 Japanese, 169 Chinese, 251 Hawaiians, and 639 Caucasians. In the same period, 181 demonstrations were made. The growers are coming to realize the nature of their difficulties, and enthusiasm is gradually replacing the suspicion and indifference with which the station's efforts were received in 1916. It is the aim of this division to cooperate with the county agents rather than with individuals, and all parts of the islands are now being reached promptly by station propaganda.

PUBLICATIONS.

To meet the increasing demand for information on the part of emergency gardeners, extension bulletins[1] were published on methods of combating garden pests and on bean spot disease. In the manuscript of a bulletin on the diseases of the Irish potato in Hawaii, now practically completed, the large number of diseases which affect the potato crops are described and illustrated, and methods are suggested for the amelioration of conditions. Numerous popular articles on plant diseases were contributed to the local press. During the year an article on the mite disease of potatoes was submitted for publication,[2] and an article on The Wilt Diseases of Okra and the Verticillium Wilt Problem, embracing work completed by the writer at Washington prior to coming to this station, was written and published.[3]

BANANA FRECKLE OR BLACK SPOT DISEASE.

The black spot disease of banana, mentioned in the report of this division for 1917, has spread rapidly during the year and is now a serious trouble in practically all the plantations of Chinese or dwarf bananas (*Musa cavendishii*), on the island of Oahu. The bunches of fruit from badly affected plants are undersized, discolored, and unevenly ripened, thus possibly being subject to fruitfly attack, and unsuitable for export, bringing on the local market only one-fourth to one-half the price of normal bunches. A year ago this disease appeared to be confined almost exclusively to the valley of Kalihi, where it was serious, but it could scarcely be found in Manoa Valley, 5 miles distant. It is now present to an alarming extent in the plantations of Moanalua, Pearl City, Mokuleia, and Kahaluu, as well as in Kalihi and Manoa. During a recent trip to Kalihi Valley, it was impossible to find a bunch of fruit not affected.

The Hawaiian freckle or black spot disease of the leaves and fruit (Pl. VIII, figs. 1 and 2) appears to be entirely different from the banana leaf black spot disease of Jamaica described by Ashby.[4] For this reason and to avoid confusion, the name "freckle" is suggested for the Hawaiian disease.

Whether this is a new disease in Hawaii can not be decided, though the writer inclines to this view. Somewhat similar spots originating in various ways on green fruits have been noted by the growers for a great many years. The injury caused by the red spider may be confused with the early stage of the freckle disease. The writer

[1] Hawaii Sta. Ext. Buls. 4 and 8 (1918).
[2] Phytopathology, 8 (1918), No. 6, pp. 286–288.
[3] Jour. Agr. Research [U. S.], 12 (1918), No. 9, pp. 529–546.
[4] Ashby, S. F. Banana diseases in Jamaica. Bul. Dept. Agr. Jamaica, n. ser., 2 (1913), No. 6, pp. 109–112.

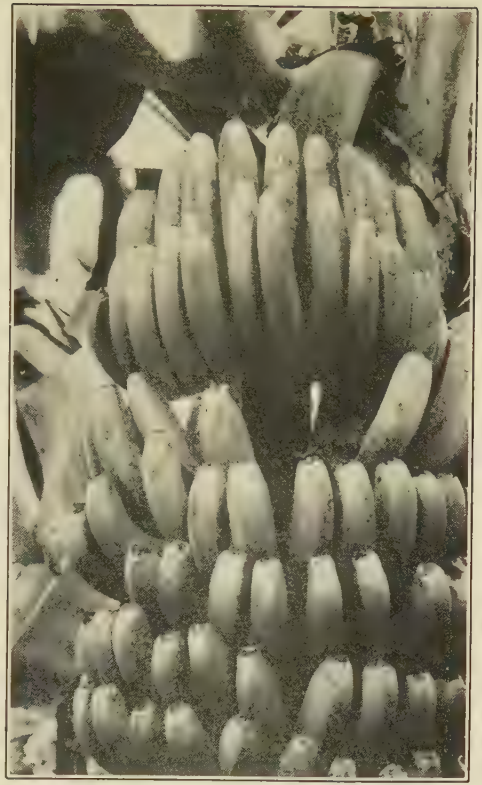
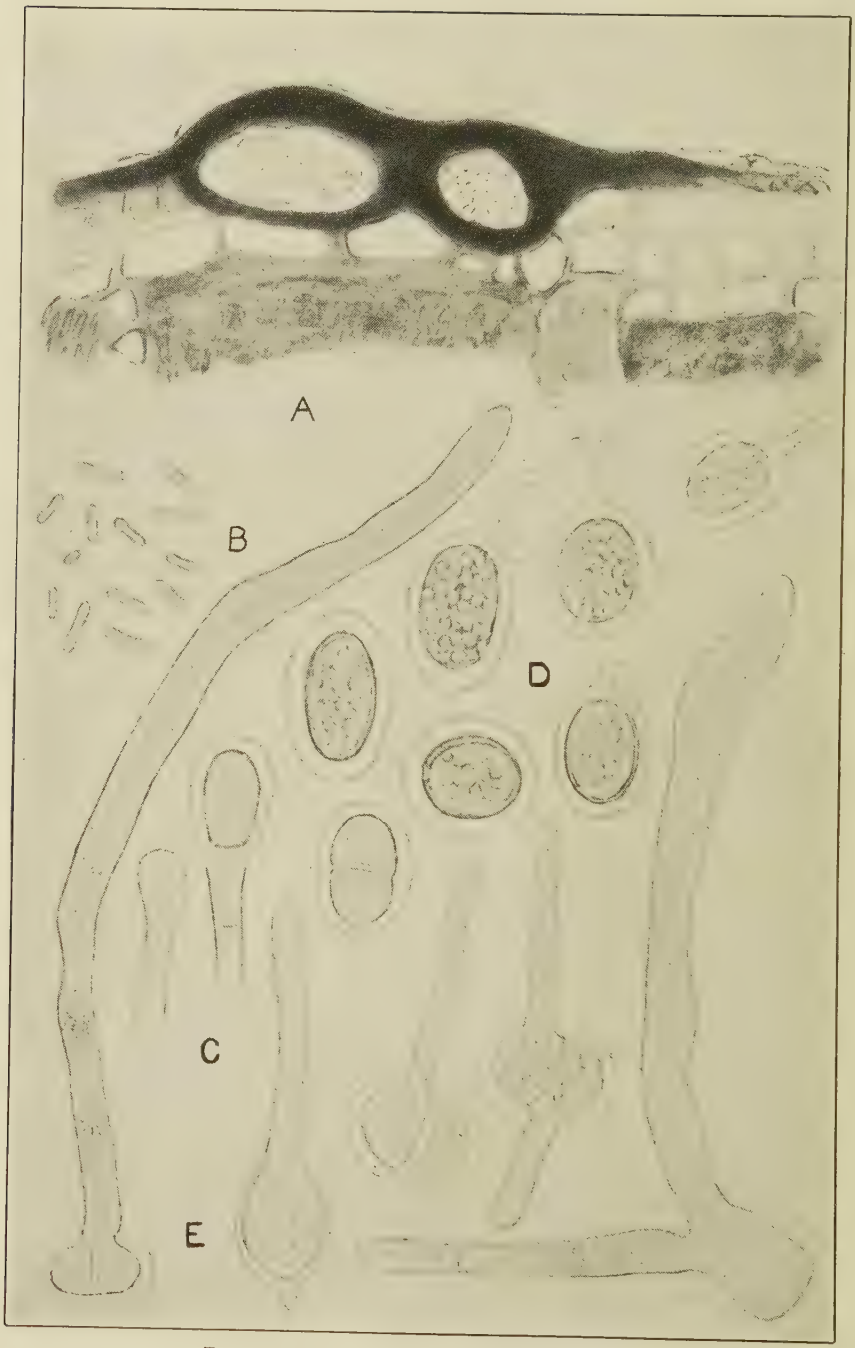


FIG. 1.—BUNCH OF GREEN CHINESE BANANAS, SHOWING FRECKLE DISEASE.

FIG. 2.—PORTION OF BANANA LEAF, SHOWING FRECKLE DISEASE.



BANANA FRECKLE (PHOMA MUSÆ N. SP.).

A, Camera lucida drawing showing pycnidia and spermagonia on green fruit (× 150); B, spermatia; C, conidiophore and forming conidium; D, conidia with gelatinous envelope and appendage; E, germination of pycnospores (B, C, D, and E, × 1000).

bases his opinion that this is a new disease in Hawaii upon the following observations, as well as upon the testimony of the majority of the growers: The disease has been localized for two or more years in Kalihi; if at any time within recent years such an epidemic as is now present in Kalihi had occurred there, the growers would have retained some recollection of it; though one year ago the disease could scarcely be found in Manoa, where the conditions are similar to those in Kalihi, it is now prevalent there to an alarming extent; the plantations of Mokuleia have been free from the disease until the past few months. On the other hand there is a possibility that this disease has previously destroyed large areas of Chinese bananas in other sections of the islands. The writer is informed that this variety of bananas was once extensively planted near Hilo, but that a disease which may have been the same as the freckle disease was responsible for the abandonment of the industry there.

Since this disease appears to be new to pathologists, no record of a disease which can be determined as identical having been found, such notes as may prove valuable to a prompt diagnosis are given here in order that the spread of the disease to other countries growing Chinese or dwarf bananas may be checked if not prevented. The following description of the disease and the organism found associated with it is in the nature of a preliminary report and further investigation is required.

Defoliation, weakened plants, ultimately becoming worthless, and undersized fruit as well as undeveloped bunches which have to be cut prematurely are all results of this disease. Although in many cases the quality of the fruit seems to be unimpaired by the surface blemish, fruit bunches at all badly affected are rendered so unsightly that they are totally unsuited for export and have to be disposed of with difficulty on the local market at about one-fourth the usual price.

Under normal conditions about 230,000 bunches of bananas per year are exported to the mainland from Hawaii, almost entirely from the island of Oahu. The total annual production of this fruit in the islands is not far from 300,000 bunches. The Chinese banana, predominantly the export variety, appears to be the only sort attacked by freckle. If other plantations suffer as severely as those of Kalihi, it would seem only a matter of two or three years before no more bananas of quality suitable for export are produced. The disease, probably encouraged in the valleys by the frequent trade-wind showers, may not prove so disastrous in the outlying plantations.

Investigation has shown that the minute, black, pustule-like spots on the leaves and green fruits are subepidermal pycnidial fruiting bodies (Pl. IX, A) containing spores (Pl. IX, B, C, D, E) closely resembling the pycnospores of *Guignardia vaccinii* and *G. bidwellii.*

The fruit spots are at first minute (about 1 millimeter in diameter), grayish, rounded, and with indefinite border, suggesting small areas of extravasated sap in the surface tissues. With a hand lens the center of the spot is seen to be reddish brown in color. The spots become more definitely round and slightly erumpent as the banana develops and are jet black in color when the fruit is "full" (ready to cut). Though the pycnidia themselves are seldom confluent, they are usually present in great numbers and so closely disposed that large areas of the leaves and green fruit are blackened. In moist weather the mature pycnidia exude white gelatinous tendrils of spores. The pycnidia are not beaked, and the ostiole, though frequently plainly to be seen, is not at all conspicuous.

The pycnidia of the fungus are to be found on the upper surface of the leaves, apparently as stomatal infections and similarly on the more exposed surfaces of the fruits. On the latter they are first observed as minute grayish "freckles" on the upper surface of the upper hands of the bunch near the base of the individual fruit. In other words, the infections occur on those parts most frequently moistened by light showers and apparently where spores lodge when carried from the leaves by rain. In diameter the pycnidia are from 60 to 150μ, and most commonly about 135μ (Pl. IX, A). Spermagonia (Pl. IX, A) containing spermatia (Pl. IX, B) resembling those illustrated by Reddick[1] are also present, though less frequently than the pycnidia. The spermatia measure 2 to 7 by 1 to 2μ, or roughly ten times the figures recorded by Reddick (apparently a typographical error in placing the decimal point).

The pycnospores or conidia are ovoid, rather hyaline, inclosed in a gelatinous envelope with one appendage (Pl. IX, D), and densely packed with globular bodies (oil droplets?). The spores when first issuing from the pycnidium are commonly irregularly ovoid and angular from mutual pressure and contact. As above noted, they resemble the pycnospores of *Guignardia* spp. Disregarding the appendage and gelatinous envelope, which are not constantly present, the spores measure 11 to 17.5 by 5 to 12.2μ. Those of *G. vaccinii* are given as 10.5 to 13.5 by 5 to 6μ by Shear.[2] Those of *G. bidwellii* measure 8.5 to 11.5 by 6.5 to 8.5μ, according to Reddick.

Although the pycnospores germinate readily in sterile distilled water in one to two days (Pl. IX, E), attempts to grow the fungus on media suitable to the culture of other fungi or on several special media concocted for the purpose have thus far failed. In most cases *Glœosporium* spp. quickly develop and monopolize the medium. This failure in culturing, accompanied by the constant

[1] Reddick, D. The black rot disease of grapes. New York Cornell Sta. Bul. 293 (1911), pp. 289-364.

[2] Shear, C. L. Cranberry diseases. U. S. Dept. Agr., Bur. Plant Indus. Bul. 110 (1907), p. 15.

development of Glœosporium in the early trials, led to the impression that a species of the latter genus was responsible for the disease. Several bacteria have also been isolated from stomatal lesions, but their relation to the freckle disease remains to be determined.

Since the pycnidial fungus which appears to be constantly associated with the disease has not yet been produced in culture and as nothing is known of its perfect stage, a satisfactory description can not be furnished. Until the perfect stage shall be found, the name *Phoma musae* is suggested for the fungus.

Phoma musae n. sp. Pycnidia globose, subcoriaceous, black, immersed to slightly erumpent, separate, ostiolate, foliicolous, and fructicolous. Conidia ovoid, hyaline, closely packed with oil droplets(?), capsulated with gelatinous envelope with one appendage, one-celled, in germination sometimes apparently becoming one-septate; measuring 11 to 17.5 by 5 to 12.2 μ. Spermagonia similar to pycnidia but slightly smaller; spermatia hyaline, appearing dumb-bell shaped, 2 to 7 by 1 to 2 μ.

CONTROL.

Only those sanitary practices applicable in all plant diseases of a similar nature can be safely recommended as control measures until further investigation shall point the way. No method of control has yet shown any promise. It is believed that cleaning up and burning diseased leaves and débris, replanting suckers from healthy plants, and spraying the leaves periodically with Bordeaux mixture and thus keeping down the leaf infection until the bunch appears and matures, will tend to reduce fruit infection. The disease appears to progress slowly and would possibly be of little consequence on the fruit if the latter were not infected by the spores carried by water draining from the blackened leaves. It may be found advisable to spray the fruit with ammoniacal copper carbonate, which would be less likely to leave an objectionable stain than would the Bordeaux mixture. As banana plantations are laid out without roads and on steep hillsides in many cases, they present considerable difficulty in the practicable application of spray mixtures. Some of the plantations on level ground, if properly laid out, would offer no more mechanical difficulty in spraying, should this method of control be found desirable, than an apple orchard or an orange grove.

A fungus similar to *Phoma musae* has been found associated with a black spot disease of algaroba (*Prosopis chilensis*) pods, but this disease does not appear to be very prevalent. Other hosts of the banana fungus or similar ones are not known to occur in Hawaii. *Guignardia bidwellii*, the cause of black rot of grapes, has not been detected.

This freckle disease of the Chinese banana is a serious menace to the industry, and if not a new disease in Hawaii, it is certainly new in

epidemic form. Those interested in banana growing are urged to realize the threatening aspects of this disease and to attempt control along the lines suggested and others which appear feasible, as increasing the vigor of the plants through fertilization, rotation, etc.

IRISH POTATO DISEASES.

Late blight (*Phytophthora infestans*) and wilt (*Fusarium oxysporum*) continue to be the most serious fungus diseases of the Irish potato in Hawaii. The potato tuber moth (*Phthorimaea operculella*) and the mite disease (infestation with an undetermined species of mite allied to red spider), together with the early blight disease (*Alternaria solani*), were especially destructive during the protracted drought of the summer of 1917 in the Kula and Makawao sections of Maui and in the Hamakua section of Hawaii. The early blight disease was then for the first time observed to be an important factor in Hawaiian potato culture.

MITE DISEASE.

The mite disease, an apparently new trouble of the Irish potato mentioned in the 1917 report of this division, is found to be much more widely prevalent and destructive than was at first believed. It has been observed thus far in the following localities, which furnishes a basis for the assumption that it occurs practically all over the islands at the lower elevations: Mokuleia, Castner, and Honolulu, Oahu; Kula and Makawao, Maui; Hamakua, Hawaii; and Hanalei, Kauai.

Experiment has shown that where the conditions are favorable for potato culture the mites may be kept off the plants by dusting with dry sulphur or spraying with lime-sulphur spray. The trouble may be avoided to a great extent by planting sufficiently early for the crop to mature before the dry season sets in. In any case it should be borne in mind that the Irish potato is a cool-weather crop and that during the dry season the climate of Honolulu and other localities near sea level is not well adapted to its culture. Apparently the mite disease will not prove a serious menace to the potato industry at elevations of 1,500 to 4,000 feet except in abnormally dry years. In this contingency, spraying and dusting with sulphur offers a practical means of control.

LATE BLIGHT.

During the year considerable additional evidence was accumulated showing the effectiveness of Bordeaux mixture as a preventive of late blight. Increased yields of sprayed over unsprayed plats of 50 to 200 per cent were obtained. Much of the evidence was of a nature to appeal to the eye, and accurate figures were secured in few

FIG. 1.—ROWS OF HAMAKUA HYBRID POTATOES RESISTANT TO LATE BLIGHT WITH BADLY BLIGHTED ROWS OF EARLY ROSE VARIETY BETWEEN.

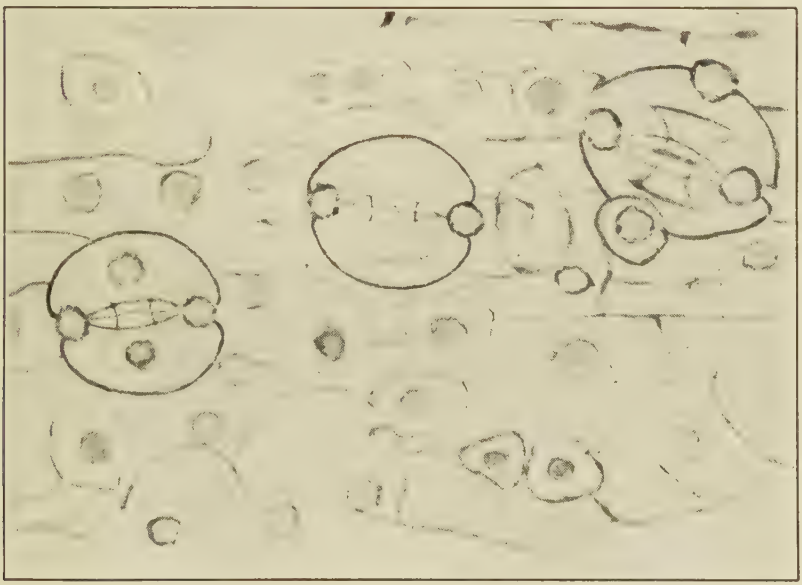


FIG. 2.—STOMATA OF PINEAPPLE LEAVES.

Camera lucida drawing (× 1000).

FIG. 1.—DEMONSTRATION SUBSTATION, HAIKU, MAUI.

FIG. 2. FERTILIZER EXPERIMENTS WITH ALFALFA, CASTNER SUBSTATION. FERTILIZER DRILLED IN ROWS IN CENTER, APPLIED AS SPRAY ON RIGHT.

cases. Owing to the conflicting results where badly wilt-infected stands were sprayed, some growers remain to be convinced of the efficacy of the treatment. No amount of spraying in stands badly infected with wilt (*Fusarium oxysporum*) and rosette (*Rhizoctonia* sp.) will serve to bring forth a good yield, spraying in such stands serving only to furnish a basis for criticism of spraying in general. Only in stands of potatoes worth spraying to prevent the late blight can the effectiveness of Bordeaux mixture as a preventive spray be properly appreciated. In view of the conflicting evidence of the value of Bordeaux, efforts to improve the potato industry may well center about the practice of seed selection and crop rotation for the improvement of the general vigor of the plants and the elimination of Fusarium wilt and rosette disease.

As an example of the value of Bordeaux spraying may be cited the 7-acre crop of potatoes grown this spring at Kemoo farm near Castner, Oahu. This crop was sprayed thoroughly, and although it was attacked by the late blight, this disease was held in check by prompt and effective treatment at critical times. It is estimated that this crop will yield about 85 bags per acre of as fine potatoes as can be raised anywhere.

A potato variety resistant to late blight.—A potato variety originated by Miss K. Yamato, of Honokaa, Hawaii, is reported to be much more successfully grown in that locality than any other variety tried. This type of potato, which has been called the Hamakua Hybrid from the locality where it was originated, is a composite of two sorts. One parent of both sorts appears to have been the local variety known as the Portuguese Purple, which was brought to the islands from Madeira by Portuguese emigrants. One sort appears to be the result of a natural cross between the Portuguese Purple and the Burbank type, the other a cross of the Portuguese Purple with the Early Rose variety. In conversation with the originator, it appeared that exact records were not kept, though the above is essentially her recollection of the parentage of the two strains.

The Portuguese Purple variety, though not a desirable culinary type, possesses considerable blight resistance. The Hamakua Hybrid of the Burbank type is of much better quality, though lacking mealiness in cooking and having deep eyes which cause loss in peeling. Altogether it appears to be more desirable than the other strain, or Early Rose type.

The evidence in hand indicates that the Hamakua Hybrid has a very promising degree of resistance to the Phytophthora leaf blight in these islands.[1] Experiments thus far have given conflicting results, but the writer is of the opinion that failure on the part of growers to recognize the several potato diseases, as Fusarium wilt, rosette, early blight, and mite infestation, is partly responsible for

the unfavorable reports on this variety. Whether the tubers of the Hamakua variety possess resistance to the late blight rot is not known, since this phase of late blight injury is comparatively rare in Hawaii, possibly owing to its porous, well-drained soils.

At the Glenwood substation [1] two variety tests by different investigators have shown the practical value of the Hamakua Hybrid in that district, where it was successfully grown in one patch of 4 acres with a reported yield of 401 bags. The grower was so impressed with this result that he proposes to plant about 40 acres to this variety. As the Glenwood section has an annual rainfall of some 250 inches, with few days in the year without some rain, it has previously been highly discouraging to grow potatoes there, since, on account of the frequent showers and deluging rains, spraying was found to be impracticable.

The Hamakua Hybrid and the Portuguese Purple varieties have also been strikingly resistant to late blight in the cooperative tests in the gardens at Schofield Barracks, where, in order further to test the resistance of the Hamakua Hybrid, this variety was grown in comparison with the Early Rose variety. Owing to the poor soil and the lack of irrigation water, no variety yields normally there, but the differences in yield in this test are rather striking. Both varieties grew well in the first month, but at the end of 60 days the tops of the Early Rose had been destroyed by the late blight (Pl. X, fig. 1), and the 96 hills yielded only 7½ pounds of small tubers. The Hamakua Hybrid remained almost without a trace of blight through another two months of weather favorable to blight. The dry season commencing at the beginning of the fourth month, 20 hills were dug at this time, with a yield of 9½ pounds of fair-sized tubers. The rest were allowed to grow another month, but the dry soil seemed to prevent any additional growth, 58 hills yielding only 27 pounds. The average yield per hill of the Early Rose variety was 0.078 pound and for the Hamakua Hybrid 0.468 pound.

No doubt the quality of this resistant type can be greatly improved by selection and by further crosses with desirable market types. Since the Phytophthora blight is the most serious of potato diseases the world over, the practical value of a desirable market potato resistant to this disease has long been evident, and the development of such a type is the aim of investigators. Numerous varieties offering promise have been brought out in Europe, some showing considerable resistance, but they are not of the quality to win recognition on the American markets.

COFFEE DISEASES.

In Kona, Hawaii, where most of the Hawaiian coffee is grown, this crop is often considerably damaged by the sooty mold, or "fumagine," which lives saprophytically on the honeydew from certain

[1] Hawaii Sta. Rpt. 1917, pp. 46–48.

scale insects. Whether the black fungus involved belongs to the genus Capnodium or to Meliola has not been determined. In Kona the sooty mold follows commonly the green scale (*Coccus viridis*), which is present most abundantly in dry seasons and where the coffee is grown in the open. The solution of the difficulty would appear to be in the use of proper shade trees, since the green scale is not so prevalent in the shade. Coffee does best in shade such as is afforded by silk oak (*Grevillea robusta*), the monkey pod (*Pithecolobium saman*), or other trees which do not in themselves harbor the scale, the honeydew from which would fall on the coffee foliage and nourish the molds.

There is a die-back disease of coffee, as well as other troubles, in Kona, but there has been no opportunity to investigate them more than casually.

MISCELLANEOUS INSECT AND FUNGUS DISEASES.

Diseases not hitherto reported in Hawaii.—So far as is indicated by the available records, the following diseases observed during the year have not been previously reported in Hawaii:

Algaroba (*Prosopis chilensis*). Black spot of pods. Pycnidial fungus similar to organism *Phoma musae* n. sp. associated with black spot of Chinese bananas. Pycnospores appendaged, measuring 10.9 by 7.3μ. Pycnida 145 to 165μ, ostiole readily seen, 15μ in diameter.

Bean (*Phaseolus* sp.). Rust (*Uromyces appendiculatus*), leaf and pod spot (*Isariopsis griseola*).

Brassica (*Sinapis cernua*), "kai choy." White rust (*Albugo candida*).

Cactus, prickly pear (*Opuntia* sp.). Blight (*Diplodia opuntiae?*).

Carrot (*Daucus carota*). Root knot due to nematodes.

Cotton (*Gossypium* sp.) Anthracnose (*Glomerella gossypii*).

Eggplant (*Solanum melongena*). Leaf spot (*Phyllosticta hortorum*), root knot due to nematodes.

Litchi (*Litchi chinensis*). Leaf blight due to ascigerous fungus of Glomerella type.

Peanut (*Arachis hypogaea*). Wilt (*Sclerotium rolfsii*), leaf spot (*Septogloeum arachidis?*).

Rice (*Oryza sativa*). Blast (*Piricularia grisea*), stem and root disease associated with *Pythium* sp. (?).

Roselle (*Hibiscus sabdariffa*). Root disease associated with *Fusarium radicicola.*

Sorghum (*Sorghum* sp.). Smut (*Ustilago reiliana?*).

Tobacco (*Nicotiana tabacum*). Mosaic disease, root knot due to nematodes, vascular disease, Granville wilt (?).

Tomato (*Lycopersicum esculentum*). Mite disease (mite apparently the same as potato mite described on p. 40).

Potato (*Solanum tuberosum*). Early blight (*Alternaria solani*), common scab (*Actinomyces chromogenus*), tuber rot (*Fusarium coeruleum*), and tuber galls due to nematodes.

Turnip (*Brassica campestris*). Root scab (*Rhizoctonia* sp.), white rust (*Albugo candida*).

Miscellaneous fungus and insect pests.—Among other diseases and pests observed during the year were the following:

Avocado (*Persea gratissima*). Blight (*Glomerella cingulata*).

Banana (*Musa cavendishii*). Red spider.

Bean (*Phaseolus* sp.). Anthracnose (*Glomerella* (*Gloeospòrium*) *lindemuthiana*).

Cabbage (*Brassica oleracea*). Webworm (*Hellula undalis*), green cabbage worm (*Pontia rapae*), bacterial soft rot.

Coffee (*Coffea* sp.). Sooty leaf mold (*Capnodium* sp.?).

Corn (*Zea mays*). Leaf hopper (*Peregrinus maidis*); motling disease similar to yellow stripe disease of corn, cause undetermined.

Guava (*Psidium guajava*). Russeting due to red spider.

Litchi (*Litchi chinensis*). Erinose (*Eriophyes* sp.).

Mango (*Mangifera* sp.). Blight, (*Glomerella cingulata*).

Monterey cypress (*Cupressus macrocarpa*). Roaches.

Onion (*Allium cepa*). Thrips.

Potato (*Solanum tuberosum*). Tuber moth (*Phthorimaea operculella*), wilt (*Fusarium oxysporum*), tuber rot (*Fusarium oxysporum* and F. *radicicola*), and rosette (*Rhizoctonia* sp.).

Pineapple (*Bromelia* sp.). Bud rot (cause?), wilts of several types apparently not caused by parasitic organisms but suggesting malnutrition.

Taro (*Colocasia* sp.). Root rots of several forms, a species of Pythium (?) associated with most common type.

Tomato (*Lycopersicum esculentum*). Blight (*Phytophthora infestans*).

STOMATA IN THE PINEAPPLE LEAF.

In a bulletin of this station[1] Wilcox and Kelly report that they were unable to find stomata in pineapple leaves, and they conclude that true stomata are not present. To quote from these writers:

> One of the peculiar features of the pineapple leaf is the apparent absence of stomata. Hundreds of sections were made from pineapple leaves and examined under the microscope, and portions of the epidermis of the upper and under sides of the leaves were carefully examined without finding any true

[1] Hawaii Sta. Bul. 28 (1912), p. 9.

stomata. There are in some parts of the leaves pits in the epidermis in which much branched scale-like trichomes are attached. These structures are particularly numerous on the underside of the leaf near the base. The trichomes in question are supposed to be connected with the absorption of water.

In view of the prompt reaction of yellowed pineapple plants growing on manganese soil to a spray of iron sulphate,[1] examination of the surface and of cross sections of pineapple leaves was made several times, and in each case true stomata were found (Pl. X, fig. 2). They are located in the bottom of the furrows on the underside of the leaves and are present at an estimated average rate of 120 per square millimeter. They are not strikingly different from the stomata of other plants. None were found on the upper surfaces.

The guard cells of the pineapple stomata are in slight depressions below the surface of the bottom of the furrow. In sections mounted in water for examination with the microscope, they are obscured by an abundance of much-branched, scale-like trichomes and free scales from the latter. The included air bubbles in the scales render the stomata difficult to see. In surface sections cut from the under surface of a pineapple leaf which has been wiped with alcohol the stomata may be readily identified, and they are not especially difficult to find in cross sections of similar material.

REPORT OF THE AGRONOMY DIVISION.

By C. A. Sahr.

Problems affecting food production and conservation have constituted the chief work of this division, the lines of investigation having been gradually changed from the original projects to those more directly applicable to emergency food-crop production.

POTATOES.

Because of the very unfavorable soil conditions at the central station at Honolulu, all the work with Irish potatoes done by this division was carried out at the forage-crop station near Castner. In a test to determine the blight resistance of various standard varieties and the new Hamakua Hybrid potato, a planting was made of 16 hills each of Early Rose, Burbank, Hamakua Hybrid (Terry), Hamakua Hybrid (Haiku), and Portuguese Purple under date of February 5, 1918. Examination of these stands made April 1 disclosed the presence of late blight on the entire stands of the Burbank and Early Rose and blackened surfaces on the foliage on two plants of the Hamakua Hybrid (Haiku). The last of the Burbank stand succumbed to blight on April 18, followed by the Early Rose on April

[1] Hawaii Sta. Press Bul. 51 (1916).

22. The two plants of the Hamakua Hybrid (Haiku) noted as bearing blackened surfaces on their foliage April 1 were the first of the blight-resistant varieties to succumb, they being recorded as dead on May 1. The entire stands of Hamakua Hybrid (Terry), Hamakua Hybrid (Haiku), and Portuguese Purple were found to be quite dead on May 10.

RICE.

The work with rice was continued at Waiau, Oahu. Due to the rice-blast disease and an as yet unidentified root disease attacking the rice, the data obtained from the aeration, fertilizer, and green manuring tests for the 1917 fall crop are unreliable. In the rotation test with rice following taro, data from two Japanese rices, Kukiruki and Okabu, were obtained. With the Kukiruki variety the increase favoring rotation amounted to 872 pounds, or 17 per cent, with the Okabu 944 pounds, or 17.7 per cent.

CORN.

Due to the many previous failures with corn caused by persistent attacks of the corn leaf hopper (*Peregrinus maidis*), the work on corn during the early portion of the past year consisted chiefly of testing numerous varieties for leaf-hopper resistance. Seed of native Guam corn received from Mr. A. C. Hartenbower, at that time agronomist in charge of the Guam Experiment Station, was planted in June, 1917, Leaming Yellow being used as a basis of comparison. While the stand of native Guam obtained was very poor, several examinations disclosed the fact that the plants of this variety appeared to be exceedingly free from leaf-hopper attacks, while the entire stand of Leaming Yellow was heavily infested. Following this discovery, the station received a donation of 15 pounds of Guam corn from E. W. H. Broadbent, of Lihue, Kauai, with which extensive planting was made August 3, 1917, together with 10 varieties received from the Bureau of Plant Industry, United States Department of Agriculture. The results of this variety test are given in the following table:

Variety tests of corn.

Variety.	Number.	Shelled corn per acre.	Variety.	Number.	Shelled corn per acre.
		Bushels.			*Bushels.*
Boone County White	1106	0	Funk's Ninety-Day	1112	13.7
Commercial White	1107	0	U. S. Select	1113	16.2
Virginia Horse Tooth	1108	0	Yellow Leaming	1114	11.8
Hickory King	1109	0	Northwestern Dent	1115	10.9
North Dakota Flint	1110	0	Native Guam	.....	46.7
Creole	1111	39.2			

A second variety of corn (Cuban Red), a reddish-yellow sort introduced by the College of Hawaii, was likewise tested by this division at the forage crop station near Castner. While this variety also showed remarkable resistance to leaf-hopper attack, its drought-resistant qualities were found to be somewhat poor.

LEGUMES.

Two trial plantings of six varieties of button clover were made during the year. The first planting was made at the forage-crop station at Castner and the later planting in field N of the station grounds in October. In both plantings only two of the six varieties, *Medicago scutellata* (S. P. I. No. 26077) and *M. orbicularis* (S. P. I. No. 10725), made any promising growth. In both instances *M. scutellata*, while attaining considerable size, was killed off by attacks of aphids. The first growth obtained with *M. orbicularis* in the field N planting, as long as it was erect, was exceedingly promising, but as the plants became procumbent, or trailing, due to increased growth, damage caused by the wind was very evident, preventing setting of the blooms. This was further evidenced by the growth assumed by *M. orbicularis* when sown both in open places and in Bermuda-grass sod at Castner, the plants flourishing best when their trailing stems were supported and partially shaded by the grass. Other plantings of particular interest are of annual types of white sweet clover (*Melilotus alba annua*), seed of No. 1155 having been received from the Bureau of Plant Industry, United States Department of Agriculture, under F. C. I. No. 10001, and of No. 1209 from Prof. H. D. Hughes, Iowa State College. Both lots were planted at Castner, No. 1155, sown in January, coming into full bloom in early June; No. 1209, sown in April, showing favorable progress at the end of the fiscal year.

GRASSES.

Cuttings of new grasses received from the Office of Forage Crop Investigations April 24 include blue couch grass (F. C. I. No. 2378), Cayenne grass (F. C. I. No. 38746), Palm Beach grass (F. C. I. No. 02329), *Zoysia* spp. (F. C. I. No. 02839), *Capriola dactylon* (S. P. I. No. 31596), *Saccharum biflorus* (S. P. I. No. 42551), and *Andropogon emersus* (S. P. I. No. 41884). These grasses were set out in the grass garden at Castner April 30, 1918.

A sample of grass seed received under the name Prolifikeeno from John McCoy, of Fabens, Tex., was planted in two plats in field N October 2, 1917. Both plats came into full bloom in 55 days and were cut December 1, 60 days after planting, yielding at the rate of 15 and 15.7 tons green forage per acre. Its close resemblance to Johnson grass in the appearance of underground suckers shortly after cutting

made it seem desirable to eradicate the stand to prevent any possibility of its spreading as a pest.

EDIBLE CANNA.

Due to the popular demand early in the year for tubers of the edible canna (*Canna edulis*) for home gardens, various plantings of this important food crop were made from time to time to serve as sources of planting material. As the plant failed to make a luxuriant growth in some of the home gardens, chiefly as a result of poor soil conditions, a fertilizer and manuring test was inaugurated. The plats, consisting of 10 hills each 3 feet apart each way, were planted September 28, 1917, and harvested June 12, 1918. The results of this experiment are given in the following table:

Fertilizer test with edible canna.

Row No.	Fertilizer applied per acre.	Yield from 10 hills.			Estimated acre yields.	
		Number of tubers.	Weight.			
			Tubers.	Tops.	Tubers.	Tops.
			Pounds.	*Pounds.*	*Tons.*	*Tons.*
1	Ammonium sulphate, 250 pounds; nitrate of soda, 150 pounds	283	170	151.5	41.14	36.66
2	Ammonium sulphate, 250 pounds; superphosphate, 250 pounds; sulphate of potash, 250 pounds	248	177	155.5	42.83	37.63
3	Check	201	117.5	79	28.43	19.11
4	Barnyard manure, 20 tons	271	169	129.5	40.9	31.34
5	Ammonium sulphate, 200 pounds; superphosphate, 100 pounds; sulphate of potash, 100 pounds	167	93	84	22.57	20.32

In conjunction with the fertilizer test with edible canna, a test was made involving two different types of tubers (cylindrical to tapering and spherical to oval), with the object of obtaining definite data on the yields from the two tuber types used as sets. The results of this test, which included 25 hills of each type, are summarized in the following table:

Comparative yields from cylindrical and spherical tubers of edible canna.

Row No.	Type of tuber.	Weight of washed roots.	Estimated acre yields.
		Pounds.	*Tons.*
1	Cylindrical	382.5	37.13
2	Spherical	335.5	32.02
	Difference	47	5.11

CASSAVA.

The various stands of White Trinidad, White Waialua, and the red, bitter cassava have been maintained in order to keep up with the demand for cuttings. Cuttings of five varieties of cassava cultivated in various provinces of the Philippine Islands and received from the

Bureau of Agriculture, Manila, P. I., in early June, are already established on the station grounds. It may be of interest to note that as cassava has become established in a great many home gardens throughout the Territory, the publication in the local press of various methods of preparation of dried cassava roots and the culinary uses of these as tested out in the household of the writer, has proved of great benefit to the public.

SWEET POTATOES.

Preliminary work with sweet potatoes was begun by this division during April, 1917, the object in view being to supply propagating material for distribution, but the demand for cuttings became so great as to make it seem advisable to broaden materially this field of work. Through the efforts of H. L. Chung, of the division of agronomy, in selection and breeding from standard types and varieties, this division is now able to distribute cuttings of varieties which are well recognized for their good producing qualities.

TIMELY ARTICLES FOR THE LOCAL PRESS.

In order to reach the people of the islands promptly with practical information along food and feed production lines, the following articles were prepared for the local press and printed during the year: Crop Protection and Fumigation, Tepary Beans, Sweet Potatoes, Rape for Hogs and Poultry, Pork Production, Aphis Control, Guam Corn, Cassava Flour, Guam Corn *v.* Seed Corn Shortage, Buckwheat, Potato Spraying by Army Gardeners, Household Uses for Cassava, Doubling Corn, Broom Corn, and Napier Grass.

FORAGE CROP AND FOOD CROP PROBLEMS AT CASTNER, OAHU.

The most important work of the year consisted in keeping an accurate record of the yields of the forage crops involved in the soil-heating and manuring test begun in 1917.[1] The first year's results with the most promising crops are given in the following table:

Comparative yields of forage crops on manganese soil given heat treatment and stable manure.

Crop.	Division A, no treatment.	Division B, ditched soil heated.	Division C, level soil burned over.	Division D, stable manure, 33 tons per acre.
Grasses:	*Tons.*	*Tons.*	*Tons.*	*Tons.*
Rhodes	16.9	32.9	25.5	40.4
Teff	.....	3.7	3	7
Sudan	.7	6.1	5.5	13.6
Wilder	3.3	7.7	8.3	20.4
Tunis	4.1	11.5	7.1	42.9
Sorghums:				
Adyiba	5.2	13.4	14.1	53.2
Sugar Drip	14.4	13.6	22.8	40.7
Legumes:				
Peruvian alfalfa	3.5	11.5	10.2	16.4
White sweet clover	1.6	7.2	7.3	18.1
Edible canna:				
Tubers	5.5	12.68	11.96	21.43
Tops	5.55	12.15	17.15	28

[1] Hawaii Sta. Rpt. 1917, pp. 53, 54.

A further study of the effect of iron compound spray upon the yields of Peruvian alfalfa and Japanese cane is being made. In the test of applications of copperas to the alfalfa, a 0.25 per cent solution was used in each instance, first one week after each cutting and again two weeks later, after which the stands were allowed to come into full bloom before cutting. The Japanese cane was sprayed every two weeks for a period of six months, beginning in April, 1917. Following the spraying periods, the stand was laid by until harvested on April 30, 1918. The results of this work are summarized in the following table:

Effect of copperas solution upon alfalfa and Japanese cane.

Plat.	Crop.	Treatment.	Yield on—					
			July 17, 1917.	Oct. 29, 1917.	Feb. 14, 1918.	Apr. 18, 1918.	May 16, 1918.	June 26, 1918.
			Pounds.	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*
I-a	Peruvian alfalfa	Sprayed	554	1,148	1,013	1,013	1,913	1,419
I-b	do	Unsprayed	459	959	593	608	1,481	432
	Increase due to spraying—per cent.		20.7	18.6	69.1	66.6	29.1	228.4
II-a	Peruvian alfalfa	Sprayed	931	1,305	769	1,485	3,434	1,285
II-b	do	Unsprayed	809	1,244	688	1,133	2,570	1,121
	Increase due to spraying—per cent.		15	4.9	11.8	31	33.6	14.6
III-a	Japanese cane	Sprayed				7,610		
III-b	do	Unsprayed				5,291		
	Increase due to spraying—per cent.					43.5		

Due to the marked increase in the yields of alfalfa obtained as a result of spraying with copperas solutions, spraying and drilling tests were begun with other fertilizers and fertilizer solutions used in conjunction with the iron sprays (Pl. XI, fig. 2). The same alfalfa plats were used in this test as with the iron sprays alone. The check row for the iron spray of each plat was likewise check row in this test. The results of this test are given in the following table:

Effect of spraying alfalfa with iron and fertilizer compounds.

Kind, amount per acre, and method of treatment on Sept. 28, 1917.	Yield on—			Kind, amount per acre, and method of treatment On Apr. 15, 1918.	Yield on—	
	Sept. 29, 1917.	Feb. 14, 1918.	Apr. 8, 1918.		May 16, 1918.	June 26, 1918.
Lime, 118 pounds:	*Pounds.*	*Pounds.*	*Pounds.*	Lime, 1,000 pounds:	*Pounds.*	*Pounds.*
Drilled	1,013	243	296	Drilled	523	555
Sprayed (milk of lime)	1,467	1,518	2,824	Sprayed (milk of lime)	3,785	1,775
Sulphate of potash, 118 pounds:				Sulphate of potash, 250 pounds:		
Drilled	945	541	594	Drilled	6,296	432
Sprayed	1,214	971	1,254	Sprayed	2,803	1,387
Check:				Check:		
Drilled rows	1,959	593	608	Drilled rows	1,481	432
Sprayed rows	1,244	688	1,133	Sprayed rows	2,570	1,121
Copperas, 5 pounds:				Copperas, 5 pounds:		
Drilled	1,148	1,013	1,013	Drilled	1,913	1,419
Sprayed	1,305	769	1,485	Sprayed	3,434	1,285
Superphosphate, 118 pounds:				Superphosphate, 250 pounds:		
Drilled	2,540	3,040	2,959	Drilled	2,438	5,154
Sprayed	2,830	2,226	3,289	Sprayed	7,593	3,084

Other work of importance was the inauguration of a fertilizer and manuring experiment with cassava and edible canna. In conjunction with this test a second fertilizer experiment without the use of manure was also inaugurated before the dry season set in.

REPORT OF THE GLENWOOD SUBSTATION.

By R. A. Goff.

The primary object of the work carried on at the Glenwood substation during the past year was to demonstrate that desirable and economic food and forage crops can be grown in the Glenwood district and to put these results directly before farmers and agricultural producers. The various nationalities represented among the growers make it difficult to distribute information through bulletins and circulars. To overcome this difficulty, two days of each week were spent in actual demonstration work among the farmers. The result has been to bring home to the local farmers the possibility of relying less on imported feeds and food crops and to depend to a greater extent on home-grown feed for stock.

DAIRY.

Glenwood has been for some time a dairy district from which considerable quantities of butter have been sent to the local markets. However, a serious difficulty in the way of successful and profitable dairy farming has been the dependence of the local dairymen on imported milled feeds to supplement the native grasses which can easily be grown in the district. Dairying is nearly always more profitable where the products grown on the farm are marketed in the form of milk or butter, but when it is necessary to import all or nearly all of the concentrates, a large share of the profit that should go to the dairyman is paid to the transportation companies and grain farmers who have produced the milled feeds. To overcome this difficulty, experiments with 20 or more forage crops have been carried on, two or three of these having given very promising results. It has been demonstrated on small plats that two crops of corn a year can be successfully grown, and when a practical method of drying the corn has been worked out, a valuable concentrate will be available for local dairymen. The small grains head out well but do not fill, and work is being done in saving the occasional grains that mature in an effort to obtain seed that will be acclimated to the region.

ALFALFA.

Alfalfa is not usually considered a concentrate, but when made into meal it is practically the equal of imported wheat bran. Work with alfalfa was carried on from the point to which it had been de-

veloped in previous years at this station. It has been demonstrated that alfalfa can be grown in this region if the cutworm and snail can be overcome, and a demonstration plat has been planted with seedlings transplanted from small flats which were protected from the rains and treated with poison mixtures applied when the plants were attacked by pests. Within a year from planting this plat had produced at the rate of over 30 tons of green feed to the acre, in spite of the fact that the distance between rows and between plants in the row was greater than would be used in actual field operations. For some time during the past year seed was planted in the flats because it was not believed possible to plant directly in the field where it would be difficult to combat cutworms on account of the heavy rainfall which promptly destroys the efficiency of any poison which can be applied. Later it was found that seed planted in small nursery beds could be protected by hand picking and other methods used in cabbage culture, and from one of these plats 5 by 75 feet enough seedlings were secured to plant an acre with the rows 2 feet apart and the plants 1 foot apart in the row. This acre is now in good condition, and practically no replanting has been necessary. After one or two trials, seed planted in rows at the distances desired for the permanent field were grown in poor soil that had been carefully fertilized, so that it is now believed that the planting in seed flats and nursery bed is unnecessary, if a time is chosen to plant when the cutworms are not plentiful. This last can be determined by observation.

As it was realized that the quickest way to get these results to planters interested in saving on their feed bills was by local demonstration, it was decided to furnish seed and assistance in planting, together with any work necessary in combating pests, to anyone who would prepare an area of sufficient size to make it worth while. At the present time these cooperative planting projects are under way in a number of places, including a homestead in Laupahoehoe, a plantation, a school attended by over 100 boys from different parts of the island, a tract owned by a cooperative planters' association at "Twelve Miles" on the Volcano Road, and two of the dairy farms in the Glenwood district. As these plantings are at elevations ranging from sea level to 4,000 feet, they will give an idea of the adaptability of alfalfa to the different climates on this island.

POTATOES.

Plantings of Irish potatoes made at various times throughout the year have shown that yields of 100 bags (100 pounds each) or more to the acre can be obtained when planting is done in the two seasons beginning in July and August and in February and March. The

table given below shows the results obtained from a variety test on plats of 240 square feet started in the early part of September, 1917:

Variety test of potatoes.

Variety.	Yield from plat of 240 square feet.	Estimated acre yield.
	Pounds.	*Bags.*
Hamakua Hybrid (light variety)	59.5	108
Hamakua Hybrid (dark variety)	51.2	93
Portuguese Red	48	87.2
Eureka Extra Early	33.7	61.3
State of Maine	23.1	42
Vermont Gold Coin	19.4	35.7

The first three of the above-named varieties seem to be better adapted to the local climatic conditions and are more blight resistant. The last three consistently give lower yields, although reported to be blight resistant in the eastern part of the United States.

That the Hamakua Hybrid potato will produce as well on larger areas as on the small plats at the experiment station has been demonstrated by Mr. Yamanaka, a cane planter from "Nine Miles" on the Volcano Road, who planted 4 acres within a half-mile of the Glenwood substation and secured 408 bags of potatoes, practically all of which were of marketable size. Mr. Yamanaka now has an increased area in potatoes, and others in the Glenwood district have planted from 5 to 10 acres. The indications are that the potato industry of this region will be considerably increased in the near future.

FIBER CROPS.

Trials have been made with sisal, New Zealand flax, hemp, flax, and Manila hemp in an effort to find some crop to serve as the foundation of a fiber industry and bring into intensive and profitable cultivation some of the areas near Glenwood which can not be used for sugar-cane cultivation. With the exception of Manila hemp, all these crops have shown some promise, the flax having made an even growth and attained a height of about 3 feet.

POULTRY.

Records of pure-bred stock of Single Comb White Leghorns and Rhode Island Reds, the breeds of poultry kept at the substation, and individual trap-nest records have been continued as in past years in order to maintain high egg-laying strains by selection and to secure hatching eggs for distribution throughout the island. An artificial brooding system was built into two houses capable of housing 350 chicks at one time, and in these houses the chicks from the station

incubators and chicks sent to the station for rearing have been placed. One new incubator was obtained, and 600 eggs can now be set at one time in the station incubators. A floor has been put in a house 32 by 16 feet, and this is being used for the chicks after they come from the brooders and before they are able to resist the diseases which attack them if they are allowed to run on the wet ground. Three hundred pullets hatched during the last year are beginning to lay.

Because of the prohibitive prices on imported poultry feeds, a great many farmers have disposed of their stock, and unless some of the feeds necessary can be grown on the farms those who still remain in the business may be forced to do the same. Trials are being made with grain crops such as corn, buckwheat, oats, sunflower, sorghums, and certain varieties of beans, and it is thought if some of these can be successfully grown and fed in connection with such green feeds as rape, kale, alfalfa, and clover that the imported feeds can be eliminated.

EDIBLE CANNA.

Edible canna can be used as a substitute for potato and makes an excellent food for swine. The tops, growing to a height of 8 feet or more, were fed with success to large and small pigs when the leaves and stalks were cut into 8-inch lengths and fed immediately after cutting. The entire plant is relished by hogs, which thrive on it with little other feed besides waste from the house. Plats of edible canna were planted and cultivated at the substation last year and distributed to those who wished to plant.

UPLAND RICE.

Three varieties of upland rice were planted. Two of these did not germinate, but the third is in good condition, and if some seed can be matured which will be better acclimated, the growing of this food can be introduced in the Glenwood region.

HOG FEED PRODUCTION.

That there is a possibility of raising hogs economically near Glenwood is indicated by the growth of peanuts, cassava, and edible canna at the substation. The roots of the first two and the entire plant of the last make a sufficient variety of fattening feeds to mature hogs, especially when they are pastured on alfalfa. Pure-bred hogs are being kept by four farmers in Puna, and as they have had little trouble with sickness in their herds, it appears that a good return for time and money can be realized if the planters can raise their own feeds. Approximately 1,400 pounds to the acre of peanuts in the shell was secured at the substation, while the edible canna has pro-

duced tubers at the rate of 31 tons to the acre. Yields of cassava have not been definitely ascertained, but its growth at present is promising.

BAMBOO GRASS.

Bamboo grass, a promising feed for dairy cows, has yielded over 7 tons of green feed to the acre from a 6-weeks' ratoon growth, and since it is relished by cattle, even when mature and seemingly too coarse to be appetizing, it may become a valuable feed in this region.

SWEET POTATOES.

Two varieties of sweet potatoes, the Madeira and New Era, were planted in May, 1917, and after 8 months' growth produced 90 and 125 bags of 100 pounds each to the acre, respectively. As lack of warm weather and too much wet weather seem to retard the growth of sweet potatoes in this district, they make a less profitable crop than Irish potatoes.

VEGETABLES.

Seed of 40 varieties of vegetables were obtained from a mainland seed firm and compared with similar lots of seed bought in Honolulu and on the local markets. Brussels sprouts, cabbage, carrots, salsify, cress, endive, leek, lettuce, turnips, radishes, and asparagus all made a good growth from the seed obtained in the three places, and can apparently be grown successfully here, while most other vegetable crops easily grown in the lower elevations either do not germinate or make too slow a growth to be promising.

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